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ECONOMIC LIVES OF ADMINISTRATIVE USE VEHICLES.(U)
AUG 79 J J STREILEIN
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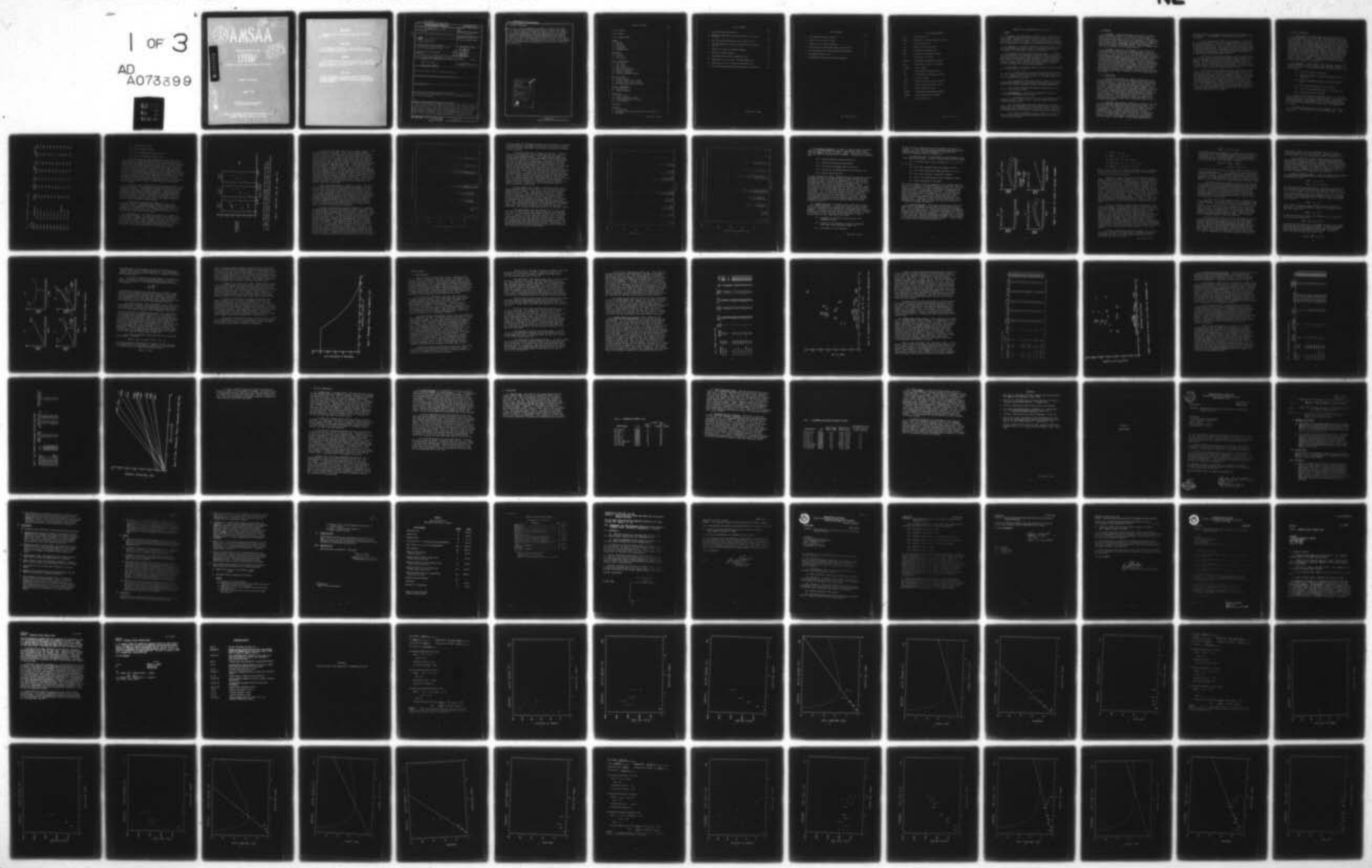

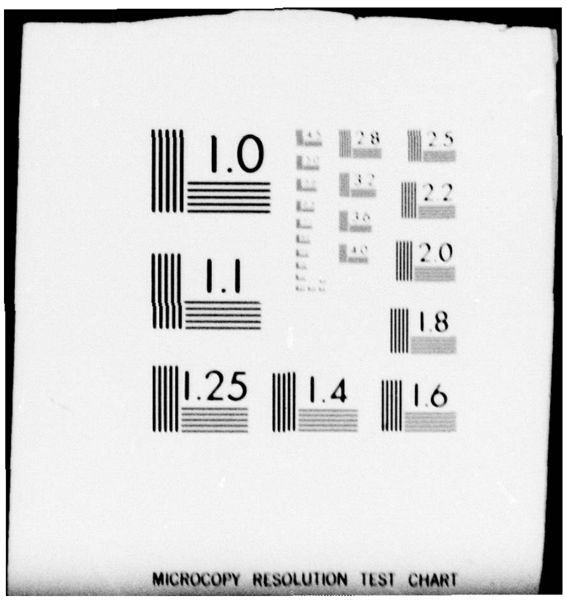
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Current Army guidance on economic lives and maintenance man-hour standards for Administrative Use Vehicles (AUV) dates from 1963. This study was requested to update that guidance. Data from the TRADOC Administrative Use Vehicle Management System and a special Sample Data Collection effort were analyzed using linear regression techniques. Estimates of maintenance man-hour requirements based on vehicle age and yearly usage were developed for ten vehicle types. Economic lives in age and in accumulated mileage were developed for the same ten

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20. ABSTRACT (Continued)

vehicle types. Three recommendations are made as a result of this study: (1) that the study results for maintenance man-hour standards and economic lives be adopted, along with a schedule for future reviews of this guidance; (2) that an Army organization be given the responsibilities and resources to periodically review economic lives and maintenance man-hour standards, to expand this study to additional vehicle types within the AUV fleet and to other fleets, such as the Maintenance and Service Vehicles, and to develop improved methodology; and (3) that consideration be given to the establishment of an Army-wide AUV maintenance management data base in order to facilitate future analyses.

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LIST OF ABBREVIATIONS

ACQ	- acquisition cost
AMSAA	- Army Materiel Systems Analysis Activity
ASC	- average system cost
AUV	- administrative use vehicle
CMC	- cumulative maintenance cost
CMM	- cumulative maintenance man-hours
DA	- Department of the Army
DARCOM	- Development and Readiness Command
DODI	- Department of Defense Instruction
FORSCOM	- Forces Command
IMC	- instantaneous maintenance cost
IMM	- instantaneous maintenance man-hours
LIN	- line item number
MRSA	- Materiel Readiness Support Activity
PREL	- primary repair expenditure limit
REL	- repair expenditure limit
TARCOM	- Tank-Automotive Readiness Command
TRADOC	- Training and Doctrine Command
TSC	- total system cost

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ECONOMIC LIVES OF ADMINISTRATIVE USE VEHICLES

1. SUMMARY

1.1 Purpose - Existing guidance on vehicle useful lives and maintenance man-hour standards for Administrative Use Vehicles (AUV's) dates back to 1963. Substantial changes in vehicle characteristics and costs have occurred in the last 15 years. This study was directed in order to update Army guidance on vehicles lives and maintenance man-hour standards.

1.2 Approach - A statistical analysis was performed on data for the AUV fleet to determine economic useful lives and maintenance man-hour requirements for as many types of vehicles as possible.

1.3 Discussion - Data were obtained from two sources: the TRADOC Administrative Use Vehicle Management Information System and a special data reporting system from six Army installations. Various mathematical models were tried to determine which would best represent the observed data. Finally, a class of equations was choosen as best representing the data. Economic useful lives and maintenance man-hour standards were then determined from estimated model parameters.

1.4 Conclusions - The following general conclusions have been reached as a result of this study effort:

1.4.1 Economic useful lives and maintenance man-hour standards for AUV's can be calculated from currently available data (Tables 6 and 7). This information on lives and man-hours is a valuable management tool in an effort to reduce costs.

1.4.2 Dedication of additional analysis resources to the Army AUV management program would provide better information and thus larger benefits to the Army by continuing studies and improving methodology.

1.4.3 An Army wide AUV data reporting program would greatly simplify future analysis efforts.

1.5 Recommendations - The following recommendations should be considered for implementation by the Army.

1.5.1 Administrative Use Vehicle lives and maintenance man-hour standards, as given in Tables 6 and 7, should be adopted along with scheduled periodic reviews.

1.5.2 An organization within the Army should be given the responsibility and the resources to continue these studies: periodically updating AUV lives, expanding studies to additional vehicle types such as maintenance and service vehicles, and developing improved methodology.

1.5.3 Serious consideration should be given to the establishment of an Army wide AUV maintenance management data base in order to facilitate future analyses.

2. BACKGROUND

2.1 Guidance - Current Army guidance in the areas of lives and maintenance man-hour standards is derived from two Department of Defense Instructions (DODI). Vehicle lives are given in DODI 4150.4, "Replacement and Repair Guidance, and Life Expectancies for Commercial Type Vehicles," dated 5 April 1963. Maintenance man-hour standards are given in DODI 4151.10, "Maintenance Man-hour Input Standards for Commercial (Transport) Design Motor Vehicles," dated 27 December 1963. Thus, current guidance is over fifteen years old.

2.2 Taskings - Questions on the adequacy of vehicle lives and maintenance man-hour standards have increasingly been raised to the Deputy Chief of Staff for Logistics of the Department of the Army (DA). In response to these questions the Army Materiel Development and Readiness Command (DARCOM) was tasked to perform any required studies to update current guidance. DARCOM headquarters originally tasked the Army Tank-Automotive Readiness Command (TARCOM) - the Army vehicle manager to perform studies to update current guidance. However, TARCOM did not have sufficient resources available to conduct these studies. TARCOM suggested that the Army Materiel Systems Analysis Activity (AMSAA), a special systems analysis office of DARCOM, could perform the studies since AMSAA had performed similar studies on tactical wheeled vehicles. Work began on these studies in October of 1977 with a target completion date of 1979.

2.3 Data Sources

All major Army commands are required to report certain cost accounting data for AUV's by AR 58-18, "Administrative Motor Services Cost and Performance." Each major Army command has the responsibility of determining the best method for reporting the required data on its AUV fleet. The Army Training and Doctrine Command (TRADOC) and the Army Forces Command (FORSCOM) jointly developed a management information system. Their system has all vehicle information from subordinate installations reported to TRADOC or FORSCOM headquarters, respectively, for processing. The DARCOM approach has each installation prepare summary information on the installation vehicles for reporting to a processing activity. Thus, there was no single site where all AUV maintenance data could be located and no single data format to use in a complete fleet analysis.

In addition, only required information was collected for either the TRADOC/FORSCOM or DARCOM maintenance information systems. One particular data item required for the originally planned study was not being reported. This item was the vehicle age in mileage for each maintenance action. In order to obtain these data, six Army installations were directed to send copies of their AUV inventories and of all maintenance data as well as mileage for all maintenance actions to a central processing site, which was the DARCOM Materiel Readiness Support Activity (MRSA). MRSA provided preprocessing of

maintenance data into a standard format from each of the separate installations. This standardized information was then provided to AMSAA for analysis.

The six installations selected for participation in this study were the two installations from each of DARCOM, TRADOC and FORSCOM with the largest AUV inventories. The six installations actually participating were Forts Benning, Knox, Lewis, Schafter, White Sands Missile Range and Aberdeen Proving Ground. Even though all personnel cooperated fully in the data collection effort, considerable difficulties were experienced in obtaining all data because of the special nature of the effort and the many different people and systems involved.

After noting the continuing problems in smoothly obtaining the data from the special reporting effort, attempts were initiated to obtain what was available from the standard reporting systems of TRADOC and FORSCOM. This effort was also difficult, but the TRADOC data from 1977 and 1978 on its AUV fleet was finally obtained. Thus, this study uses data from the special reporting effort and from the TRADOC standard reporting system in a parallel analysis wherever possible.

Aside from vehicle maintenance histories, two additional data elements were required. These items are the replacement cost of a new vehicle of each type and an inflation adjustment factor to convert the 1977 TRADOC data into 1978 dollars for comparison purposes. These data were obtained from TARCOM. The specific vehicle acquisition costs were developed by TARCOM by inflating costs from previous contracts. The inflation adjustment used to convert 1977 dollars to 1978 dollars was 1.07 and was developed from a TARCOM study from the costs of automotive parts. This inflation factor seemed to be quite accurate since very similar results were obtained from the 1977 and 1978 TRADOC data analysis. The acquisition costs used for various vehicle types are presented in appropriate tables later in this report.

3. ANALYSIS METHODOLOGY

3.1 Data Checks - Past AMSAA studies have noted that portions of the input data contain errors that might affect the overall conclusions to be developed from the data. Therefore, the data used in this study were subjected to the same types of data checks as have been applied in previous studies. For example, data checks included: mileage and date inconsistencies, lack of any maintenance during the year, impossibly high mileage in a short time period, enormously high costs for a year, etc. These checks led to reductions in the number of vehicles on which data were thought to be correct enough for analysis. Many of these vehicles had actually been removed from service, but were retained in the data base until the end of the fiscal year. The actual number of each type of vehicle for which an economic useful life could be determined is given in Table 1. The number of vehicles before and after the data checks is included in Table 1. The number of each type of vehicle in the total Army inventory is also given.

3.2 Data Items - A large number of data items were included in the data base used in this study. However, only a few data items were considered critical to the study and were thus analyzed in depth. These data items were:

3.2.1 Vehicle year age of manufacture,

3.2.2 Vehicle accumulated mileage at the beginning of the data year,

3.2.3 Vehicle accumulated mileage at the end of the data year,

3.2.4 Total direct maintenance costs for the year,

3.2.5 Total direct maintenance man-hours for the year, and

3.2.6 Vehicle shop days for the year.

One aim of this study was to determine economic lives for AUV's. Therefore items 3.2.1, 3.2.2 and 3.2.3 were critical. It was anticipated that increasing age in years and/or miles would result in increasing maintenance man-hours and maintenance costs. The relationships arrived at as a result of this study effort are discussed in the remainder of this report.

Obviously, costs are very critical to economic life. There are a number of contributing areas to total maintenance costs. These areas are:

TABLE 1. TOTAL NUMBERS OF VEHICLES STUDIED

(LIN) Line Item Number	Nomenclature	Army Inventory	Separate Effort Before	Separate Effort After	TRADOC 77 Before	TRADOC 77 After	TRADOC 78 Before	TRADOC 78 After
B04441	Auto Sdn Cpt	5828	305	148	697	431	938	759
X39598	Trk Cgo 1/2 T	13533	1558	980	2784	2473	2758	2574
X39893	Trk Cgo 1 T	1089	193	107	183	164	161	160
X42064	Trk Ca 1/2 T	4368	386	163	860	801	768	695
X54805	Trk Pnl 1/2 T	2161	201	148	418	361	371	359
X56038	Trk Stk 1 T	1031	208	70	360	337	351	345
X56483	Trk Stk 5 T	3338	454	301	810	780	789	719
X60185	Trk Tctr 28000 GVW	2070	157	100	253	234	319	295
X61518	Trk Ulty 4X2	642	88	64	221	182	277	251
X61655	Trk Ulty 4X4	1675	216	151	379	329	401	356

(1) direct materiel costs,

(2) indirect materiel costs,

(3) direct maintenance man-hour costs, and

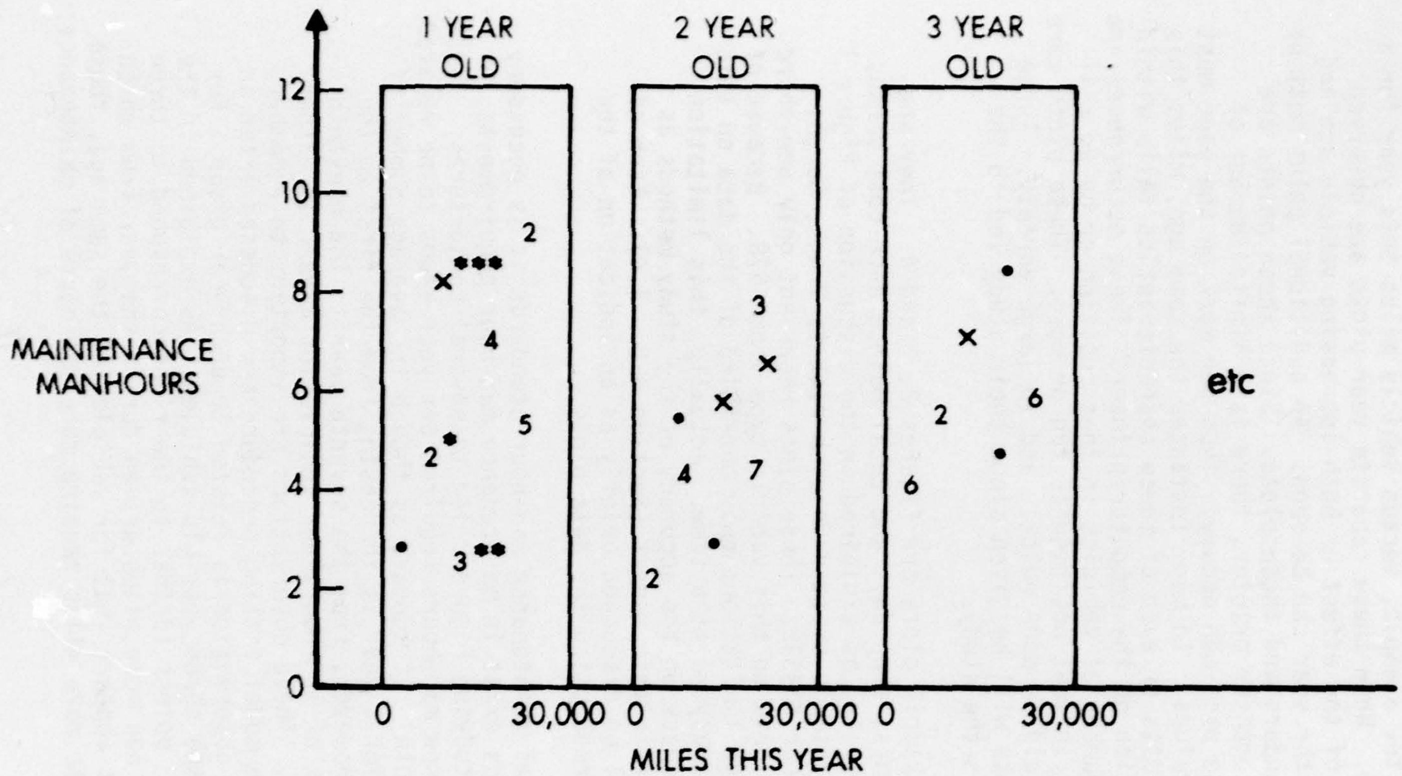
(4) indirect maintenance man-hour costs.

The direct costs can also be broken into in-house costs and contract costs, but these were combined in this study. There was also some question as to whether direct and indirect costs should be considered. It was finally determined that only the direct costs (1) and (3) could be directly related to the age of the vehicles under study. Costs entering into (2) and (4) are overhead costs or costs for items required by vehicles on a continuing basis. Therefore, it was decided that inclusion of indirect costs would make detection of direct cost trends more difficult, because of installation overhead differences and the addition of a continuing cost not related to age. Hence, data item (3.2.4), total direct maintenance costs, was calculated as the sum of sub-items (1) and (3). This study was not meant to determine total Army costs. If such costs are required, some appropriate method of estimating total overhead costs will be required.

Similarly, it was determined that the maintenance man-hour requirements to be studied to set maintenance man-hour standards should be direct maintenance man-hours. These man-hours included all in-house, military and civilian, and contract maintenance man-hours. Indirect maintenance man-hours are mostly administrative overhead and are determined by local motor pool structure. As such, these hours are relatively inflexible with regards to the increase of a few hours of maintenance on any one vehicle. Therefore, only the effect on direct maintenance man-hours of vehicle age was considered as being estimable.

The last data item examined was shop days (3.2.6). It was considered important to determine whether shop days increased with vehicle age. Since no appropriate method of costing vehicle shop days is known, this item would have to be considered separately in the determination of vehicle service life. Additional discussion on vehicle shop days is included later in this report.

3.3 Data Plotting - In any statistical analysis it is important to visually inspect the data. This check often reveals areas that should be investigated or suggests what techniques can be most correctly applied to the analysis. Plots of costs, man-hours, shop days, and miles per year versus vehicle age in years, mileage and a combination of years and miles per year are a few of the computer generated plots that were investigated. These plots guided most of the subsequent analysis.



* TWO VEHICLES CANNOT BE DISTINGUISHED AT THIS POINT ON THE PLOT

** THREE VEHICLES CANNOT BE DISTINGUISHED AT THIS POINT ON THE PLOT

*** TEN OR MORE VEHICLES CANNOT BE DISTINGUISHED AT THIS POINT ON THE PLOT

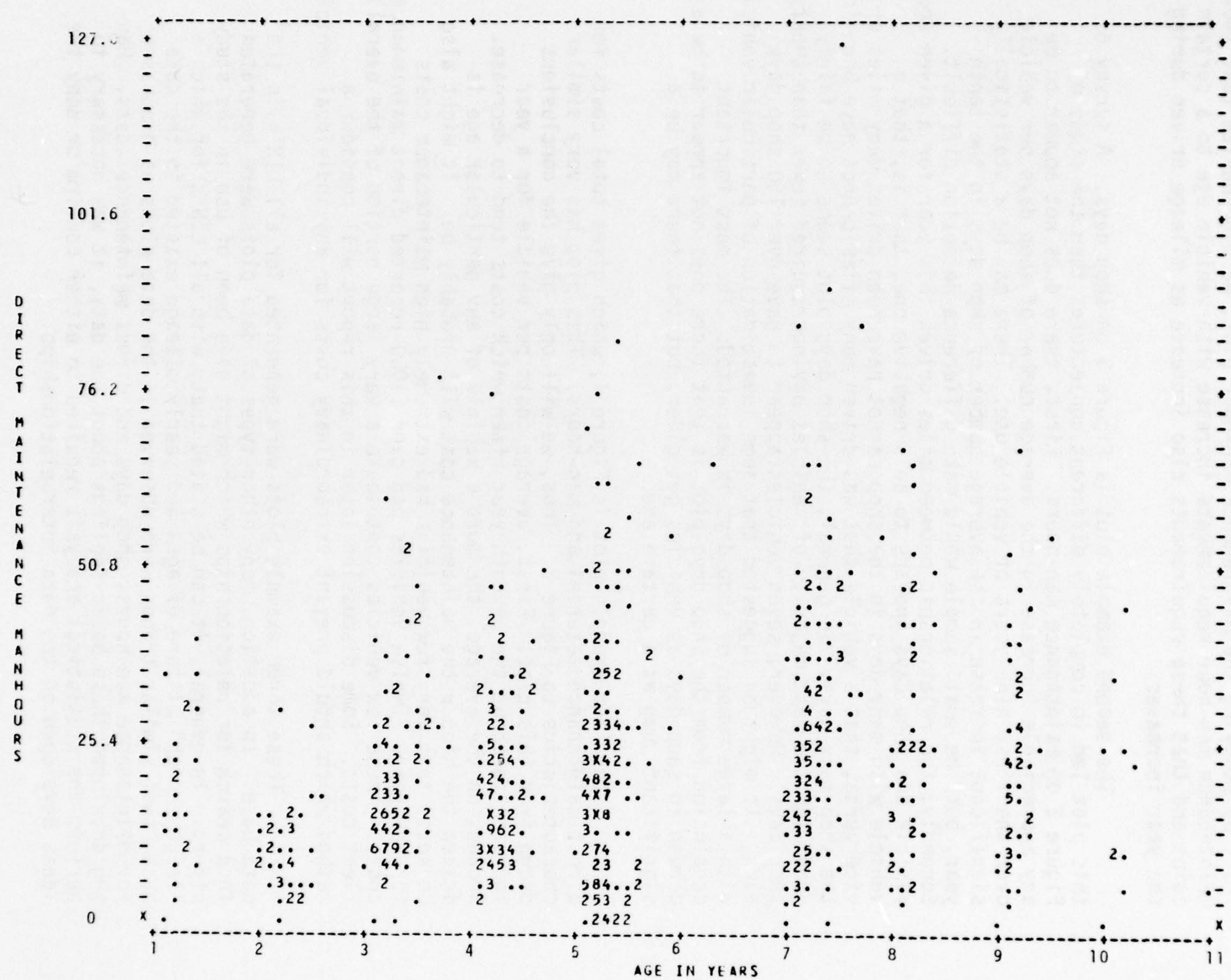
Figure 1. Generalized Age and Usage Plot.

One particularly useful type of plot is shown in Figure 1. This plot can actually be considered a series of plots pasted together. Essentially there is a separate plot for each different age of vehicle in years in the data base. Each plot gives the variable of interest, which is man-hours in the example, versus vehicle miles this year for a particular year of age. When these separate year plots are observed side-by-side, an idea of the effect of both increasing vehicle age and mileage driven during the year can be seen. An additional point must be observed in order to understand these plots. Since these points are being generated by a computer printer, there is a limited number of positions a mark on the page can occupy. Thus one mark on the page must stand for a range of values. In many instances the same age, miles this year and maintenance costs or each of these characteristics falls within the range of one position on the computer printer. These occurrences are marked by either the number of vehicles in that position or by an x if the number of vehicles in that position is ten or more. These plots were produced since they could be done quickly and in large variety. Three examples of actual plots will be given since their study led to the approach taken later in the study.

These three example plots are Figures 2, 3 and 4. They are for maintenance man-hours, shop days and total maintenance cost versus age and usage, respectively, as explained in the discussion of Figure 1. The vehicle for which data is plotted in each plot is Truck, Cargo, 1/2 Ton, Line Item Number X39598. These plots represent only one-third of the TRADOC reported data on this vehicle type from 1978. Because of computer program storage limitations only one-third of the data on this type vehicle could be analyzed at a time. Actually, this limitation provided a convenient check on the accuracy of the study methods as will be discussed later in this report (Section 4.2 - 4.4). Each of Figures 2, 3 and 4 will be discussed briefly as an indication of the type of analysis performed using the data plots.

In order to set maintenance man-hour standards it is necessary to determine what trends exist in maintenance man-hour requirements for the collected data. Studying Figure 2 led to several conjectures. First, the number of maintenance man-hours required per year seems to be related to the age of the vehicle. It appears as though the average number of man-hours per vehicle for a year is increasing from the first to the seventh year of use. However, from the seventh year to the eleventh year the average number of man-hours per vehicle for a year is either constant or decreasing. These observations are important to remember when the results of the model fitting procedure are discussed later in this report. A second observation is related to each year group. For example, just look at the three year old vehicles. As explained in the discussion of Figure 1, points further to the right correspond to three year old vehicles that had more miles driven during the year from which the data are taken. It appears that for vehicles of the same age, those vehicles that accumulate more miles require more man-hours of maintenance.

FIGURE 2 MAINTENANCE MANHOURS BY AGE AND USAGE FOR TRUCK CARGO 1/2-TON



Thus, by studying the maintenance man-hour plot, we hypothesize that yearly maintenance man-hour requirements increase with vehicle age to a certain point and that these requirements also increase as mileage driven during the year increases.

The second example plot is Figure 3 on shop days. A survey of this plot led to completely different conjectures than the study of Figure 2 on maintenance man-hours. First, there does not appear to be any appreciable increase in the average number of shop days per vehicle over the first nine years of vehicle use. There may be a statistically significant increase in the average number of shop days in the tenth year, but the small sample would make difference detection difficult. Secondly, the relationship between miles driven this year for a given age vehicle and shop days appears to be a negative one, that is, that a vehicle with many days in the shop cannot have been driven many miles or, vice versa, that a vehicle that was driven many miles cannot have been in the shop many days. In general, the shop days plot seems to be fairly good with the vast majority of vehicles having required fewer than twenty shop days. However, seven vehicles appear to have over 150 shop days each. It might be suggested that some investigation of particular vehicles with a large number of shop days is warranted. The most important conclusion from the shop days plot is that there does not appear to be a growth in shop days as vehicles get older, but that there may be a significant jump at a certain age.

The last example plot is Figure 4, which gives total costs for direct maintenance materiel and man-hours. This plot has very similar characteristics to Figure 2. Thus, we will only give the conclusions drawn from this plot. First, average costs per vehicle for a year increase to about the seventh year after which costs tend to decrease. Second, on the average, the more a vehicle of any particular age is driven the higher the maintenance cost will probably be. It might also be noted that very few vehicles had extremely high maintenance costs for one year. Twelve vehicles had over $1000 reported direct maintenance costs. These few vehicles contribute a very large portion of the overall fleet costs. Some discussion later in this report will consider a method which should prevent extraordinary costs for any individual vehicle.

These three example plots were generated for all LIN's in the data base. In addition, many other types of data plots were generated in a search for relationships which might have been of use in the study effort. In general, it can be stated that, with all LIN's for which a "large enough" mixture of ages and yearly mileage existed in the data base, that similar trends were observed in the data plots as discussed for maintenance man-hours, shop days and direct maintenance costs. Having developed these basic feelings about the data, it was necessary to perform the statistical analysis required to either confirm or deny the ideas developed on the data interrelationships.

FIGURE 3 SHOP DAYS BY AGE AND USAGE FOR TRUCK CARGO 1/2-TON

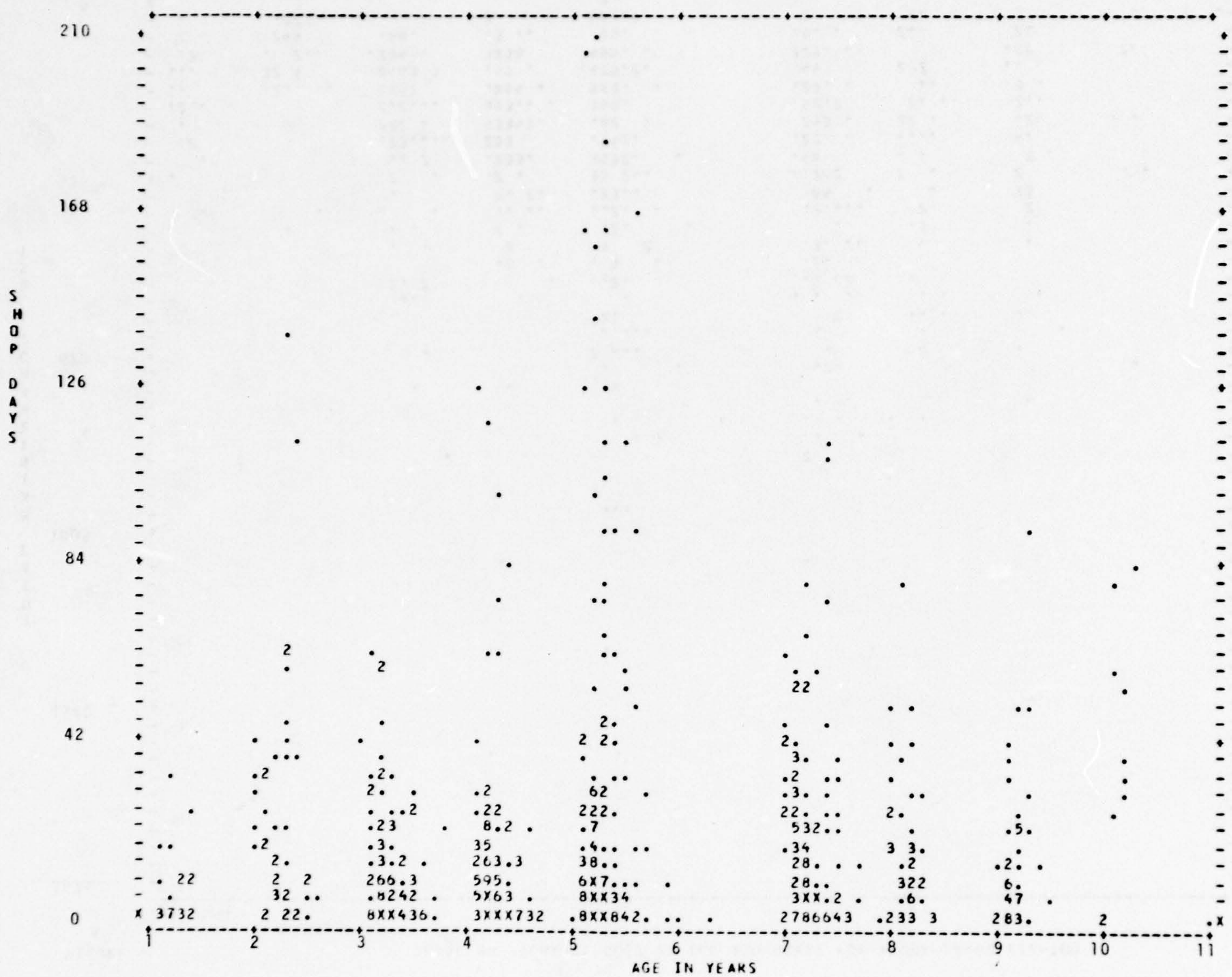
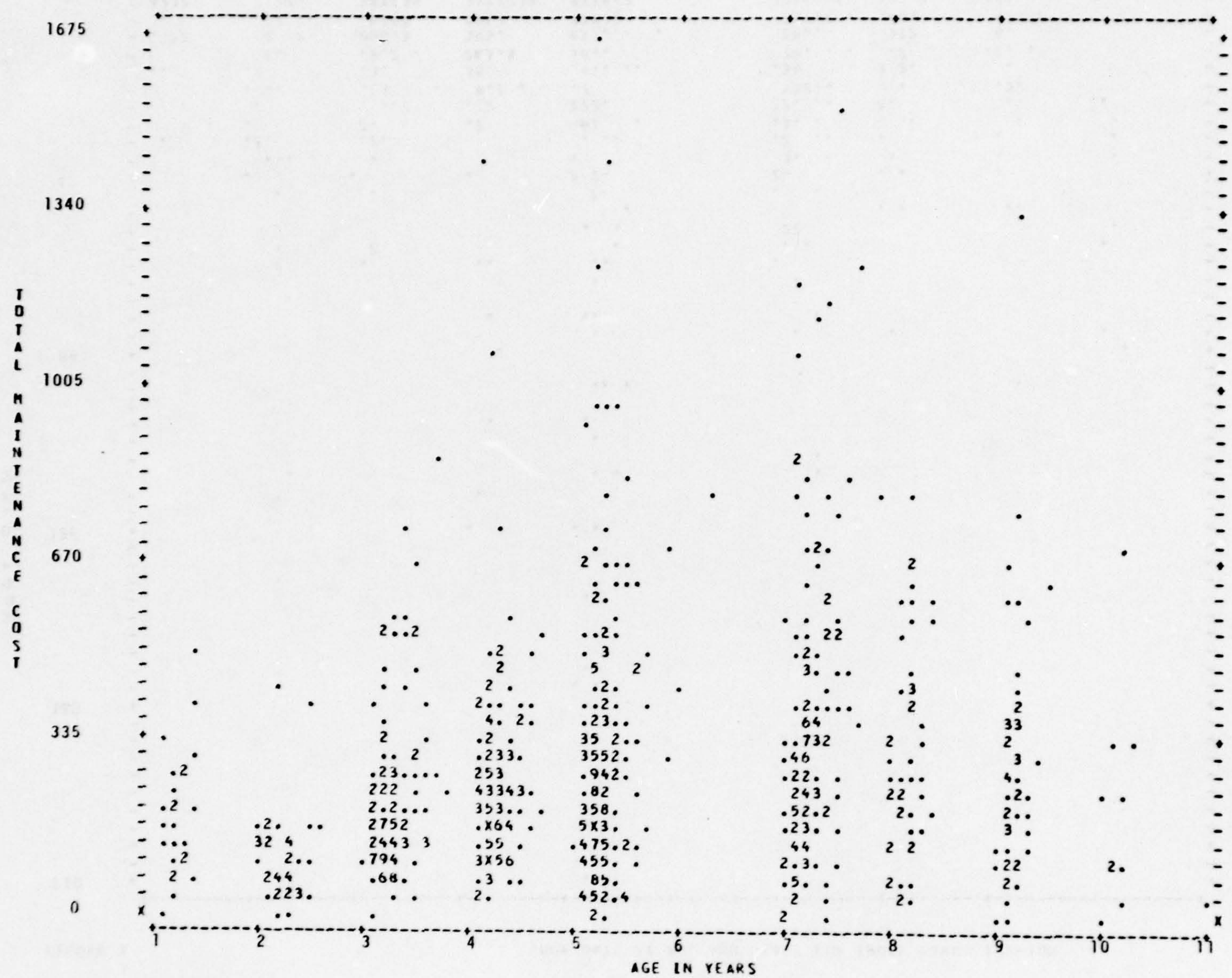


FIGURE 4 TOTAL MAINTENANCE COST BY AGE AND USAGE FOR TRUCK CARGO 1/2-TON



3.4 Descriptive Statistics - In order to visually present information about the study data without including all the computer printer plots, which are somewhat difficult to study, a number of descriptive statistics were calculated for characteristics of interest. Characteristics considered are:

3.4.1 Vehicle mileage at the end of the year,

3.4.2 Vehicle miles driven during the year,

3.4.3 Total direct maintenance cost for the year,

3.4.4 Total direct maintenance man-hours for the year, and

3.4.5 Shop days during the year.

For each characteristic, means, standard deviations and ninety-five percent confidence intervals on the mean (assuming a normal distribution) were calculated on a year of age and all years basis for all LIN's on which data were available. For LIN's for which an economic useful life could be established, these values are plotted on the graphs for each individual LIN. These graphs are contained in Appendix B to this report. It is realized that some characteristics of interest may not be normally distributed, in fact Figure 3 shows that shop days are far from normally distributed. Thus, the 95 percent confidence intervals for the mean will not be exact. However, means of any characteristic will tend to be normally distributed and in any case these descriptive statistics are just meant to be suggestive of the information in the data. Therefore, it was determined that the use of the normal assumption would provide some measure of the spread in the data without leading to seriously erroneous conclusions.

3.5 Regression Analysis - A statistical tool often used to detect trends is linear regression. This technique provides a means of computing the best estimates of the parameters for models which have linear parameters. Statistical tests are available to determine whether estimated parameters are statistically significantly different from zero. In order for the theory of linear regression to completely apply a number of conditions must be met. These conditions include:

3.5.1 Homogeneity of variances (or data spread) in the dependent variable,

3.5.2 Normality of the residuals (or errors in prediction from actual values being bell shaped), and

3.5.3 Correctness of fit of the model.

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Residual plots were examined and no serious problems were detected. Therefore, it is felt that the regression techniques employed are robust enough to determine a reasonable estimate of trends even if all statistical assumptions were not completely met.

The data were fitted to a large number of candidate models using linear regression techniques. Several of the examined variables included:

(a) Y for vehicle age in years and powers of Y, i.e., Y^2, Y^3, Y^4, Y^5, etc.

(b) E for vehicle ending mileage, and powers of E, etc.,

(c) B for vehicle beginning mileage and powers of B, etc.,

(d) 1/Y, or the reciprocal of age and its powers,

(e) 1/(E-B), or the reciprocal of miles traveled this year,

(f) linear combinations of the above.

The fitting of models to the data generated a lot of computer paper and very little information. What was learned was basically that little was gained in the explanation of vehicle maintenance costs by having more complicated models. In many cases, the parameters estimated were not statistically significantly different from zero. Even when the parameters were judged nonzero, they added very little to the predictive power of the model (i.e., the residual standard deviation or the unexplained differences between actual data and the model prediction remained large). Therefore, in order to continue the analysis, it was determined that a small number of model equations would be applied to all vehicles to conduct the analysis.

3.6 Family of Equations - The two basic characteristics which were modeled are (1) maintenance man-hours (MM) and (2) maintenance costs (MC). These characteristics can either be estimated on an instantaneous basis or on a cumulative basis. Instantaneous maintenance cost (IMC) can be predicted per vehicle age for any year Y. This prediction is written as IMC(Y) indicating that the instantaneous maintenance cost is a function of the vehicle age. Cumulative maintenance costs (CMC) can be predicted up to a particular mileage M and be denoted as CMC(M). The small number of equations chosen as candidate predictors are:

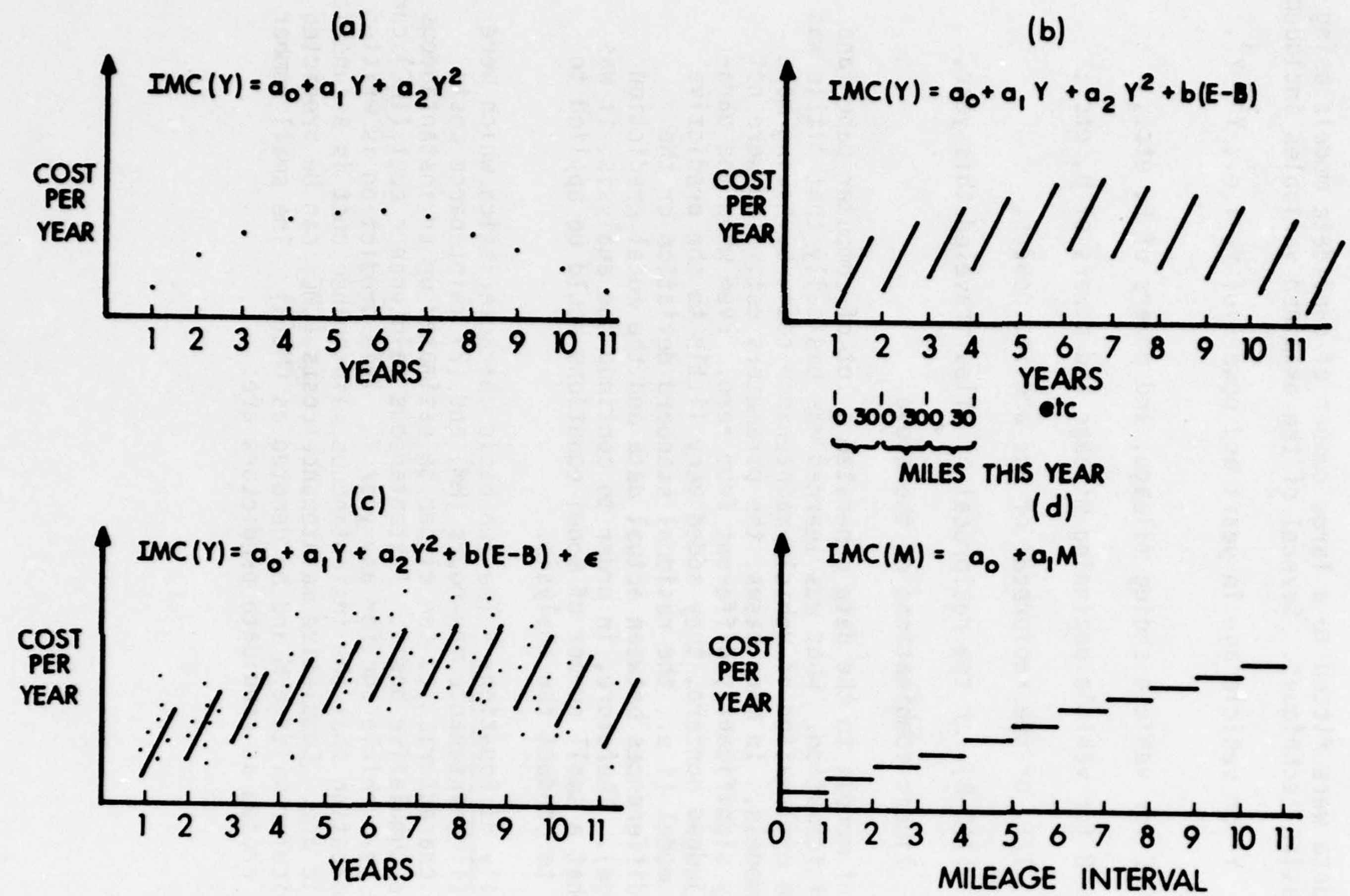

Figure 5. Example of a Family of Equations Modeled.

$$(1)\quad IMC(Y) = a_0 + a_1Y$$

$$(2)\quad IMC(Y) = a_0 + a_1Y + a_2Y^2$$

$$(3)\quad IMC(Y,E,B) = a_0 + a_1Y + b(E-B)$$

$$(4)\quad IMC(Y,E,B) = a_0 + a_1\ Y + a_2Y^2 + b(E-B)$$

$$(5)\quad CMC(E,B) = a_0 + a_1(E-B) + a_2(E^2-B^2)$$

where Y is age in years, E is ending mileage this year, B is beginning mileage this year and the a_i's and b are estimates of the parameters derived from the regression procedures.

Equations (1) and (2) have the familiar linear and quadratic shapes. For example a quadratic, equation (2), is shown in Figure 5(a). With equation (4), there is an added correction in the prediction for miles operated during a year. This type equation is plotted in Figure 5(b). Note that the more miles driven in a year, the greater will be the prediction for that years cost of maintenance. However, since it is expected that not all vehicles will cost the average amount for any given set of conditions there will be data scatter about the predicted values. Therefore, actual data might appear as in Figure 5(c) where the dots represent actual data points. This scatter would be represented statistically by the addition of a term ε to equation (4), where ε is some normally distributed random variable. The model of Figure 5(c) should be compared to the actual data plotted in Figure 4. This should provide some insight as to why these particular model equations were chosen.

It was also planned to compute economic lives based on total accumulated mileage. The previous models for estimating cost per mile for various mileages was dependent upon detecting trends in average cost per mile for various mileage intervals as depicted in Figure 5(d). However, in this study the data were too sparse to permit such an analysis. This occurrence was expected, since maintenance costs for an individual vehicle are zero for mileage intervals in which no work is performed and are extremely high for a mileage interval in which a high cost repair is needed. Past experience has shown difficulties with employment of fitting procedures to detect trends in average maintenance costs per interval when fewer than fifty vehicles were represented in each interval. There were only one or two LIN's for which the vehicles achieved the high density and distribution required for this type of analysis.

In order to continue the analysis of economic lives in terms of mileage, a procedure of fitting cumulative maintenance costs for each vehicle was used. This model assumes a quadratic cumulative maintenance cost curve of the form:

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$$CMC(M) = a_0 + a_1 M + a_2 M^2.$$

This equation predicts maintenance costs from 0 miles up to M miles. Higher order curves were attempted but were found to be no better than the quadratic case. The cost data available in this study were the cumulative cost from a beginning mileage, B, to an ending mileage, E, for the one year data collection effort. Therefore,

$$CMC(B, E) = CMC(E) - CMC(B)$$
$$= a_1 (E-B) + a_2 (E^2-B^2).$$

It was found desirable for some LIN's data to retain a constant term a_0 leading to model equation (5). This constant term often significantly improved the data fit. Such a constant term represents a fixed yearly cost, such as scheduled maintenance costs which is time and not mileage dependent. Thus, model equation (5) was fitted (for consistency) to each vehicle's direct maintenance cost, beginning mileage and ending mileage.

Each model equation was fitted to all the LIN's for which data were available. The resulting parameter estimates were then examined to determine which were statistically significantly different from zero. For many LIN's the fitted parameters were not found to be different from zero. The reasons for the lack of fit were usually too few vehicles in the data base or too few year classes of vehicles when substantial numbers of a LIN were in the data base. Only ten LIN's were represented in the proper quantities and age mixtures to allow significant fits to be estimated.

For those LIN's for which models were fit, an interesting outcome was observed. In most cases, the best fit was provided by a model of form (2) or (4). What was surprising was that the parameter a_2 was negative. This occurrence indicates a downward trend in costs after a particular age. This trend is the same type of trend conjectured about in Section 3.3 on data plotting. If this equation were blindly accepted, all vehicles should be kept as long as possible since they would be estimated to become cheaper to operate. Some explanation for this unexpected behavior is obviously required.

Present Army policy calls for vehicle replacements to be made on an age or mileage basis. Therefore, a local motor pool manager expects to obtain some replacement vehicles for his oldest vehicles. This may lead him to defer maintenance whenever possible on older vehicles. Secondly, there are maximum maintenance expenditure limits which have been set to prevent expensive repairs on older vehicles. Both of these factors may be acting to reduce the cost per year for older vehicles, even after the adjustment for mileage usage of equation (4) is made to accommodate the lower annual mileage of older vehicles.

If new longer economic lives are established, more repairs may be required to keep the older vehicles running. Therefore, current costs for older vehicles are not a good projection under a changed policy.

It was decided that a better estimating procedure would be to omit the data on the very old vehicles. When the model equations were fitted to data for newer vehicles only, a linearly increasing cost trend represented by equations (1) and (3) was obtained. These linearly increasing cost trends provide the best estimates of costs for older vehicles for changing policies. Therefore, the linearly increasing cost trends for the years before the downward cost trends have started were used as the appropriate estimators in the remainder of this analysis.

3.7 Calculus of Model Equations - In the last section, it was suggested that equations of the following two forms were most appropriate for determining cost trends:

$$IMC(Y) = a_0 + a_1 Y, \text{ or}$$

$$IMC(Y) = a_0 + a_1 Y + b(E-B).$$

The interpretation of these two equations is that costs increase linearly with age and may linearly increase for more operating mileage within a year. It will be shown in this section that only the a_1 term is important in determining economic useful lives. Therefore, when the E-B term was significant, the average annual mileage computed as a mean, as discussed in Section 3.4, was substituted for E-B. Thus, all predictive equations are of the form:

$$IMC(Y) = a_0 + a_1 Y.$$

This is simply a linearly increasing function similar to the plot in Figure 6(a). By integrating IMC(Y), an equation for cumulative maintenance cost, CMC(Y), is:

$$CMC(Y) = a_0 Y + \frac{a_1}{2} Y^2.$$

By adding acquisition cost (ACQ) to the CMC equation, total system cost (TSC) up to the Yth year will be:

$$TSC(Y) = ACQ + a_0 Y + \frac{a_1}{2} Y^2.$$

By dividing the total system cost by the number of years, Y, the average system cost per year (ASC) will be calculated. This equation represents the average yearly cost expenditure for new vehicles and maintenance costs if all vehicles were replaced in the Yth year. The graph in Figure 6(b) shows ASC which can be expressed as:

$$ASC(Y) = \frac{ACQ}{Y} + a_0 + \frac{a_1}{2} Y.$$

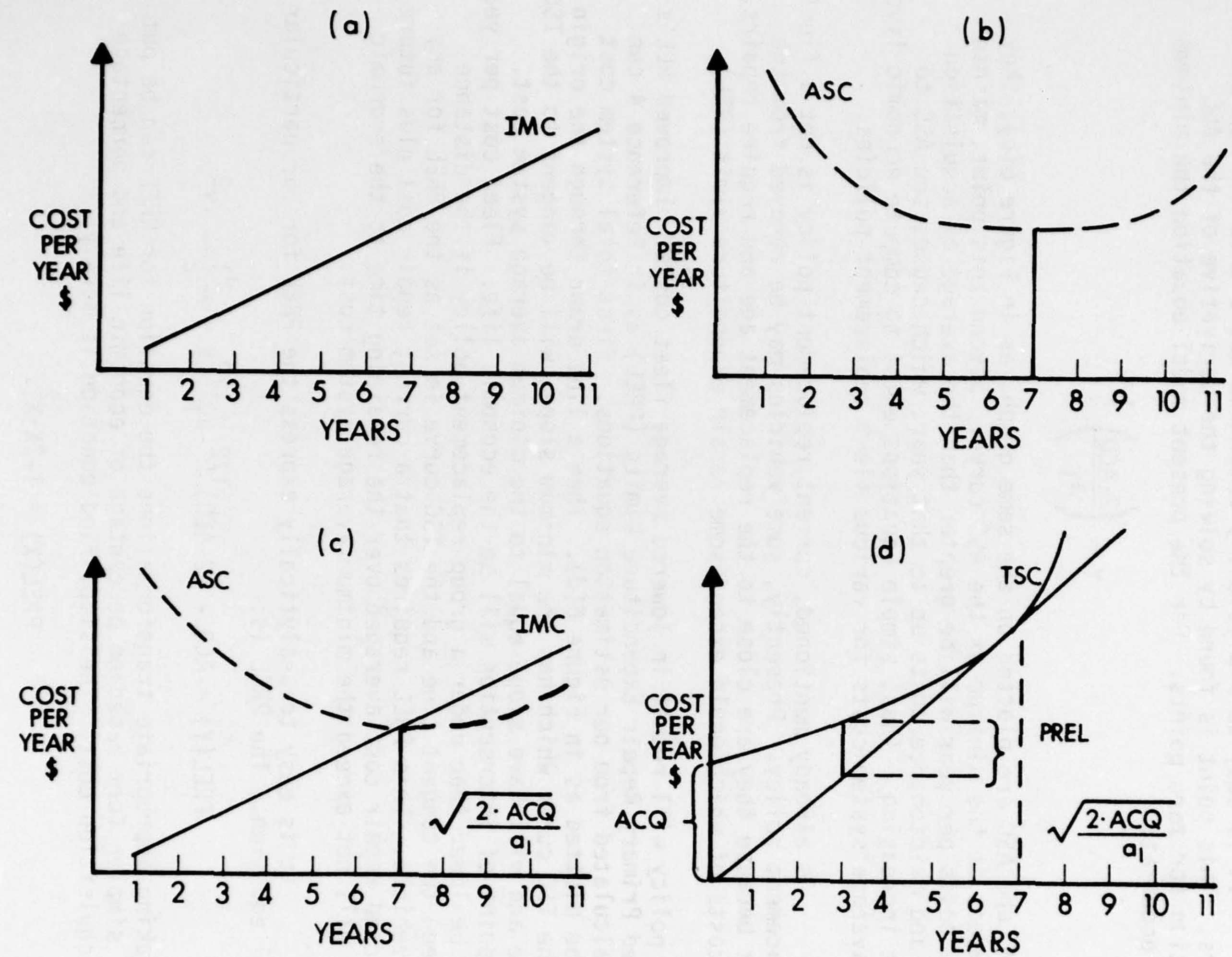

Figure 6. Calculus of Model Equations.

The minimum point of the average system cost curve would be the most economical age at which to replace each vehicle. This minimum point is normally called the economic life of the class of vehicles to which the model equations apply

It is easy to analytically determine where this minimum point occurs. This point is found by solving the derivative of the ASC equation for zero points. For the present model equation the minimum will occur at:

$$Y = \left(\frac{2 \cdot ACQ}{a_1}\right)^{1/2}.$$

If IMC and ASC are plotted on the same graph, as in Figure 6(c), they intersect at the minimum of the ASC curve. Beyond this point, maintenance costs per year will be greater than the average of acquisition cost and maintenance costs up to that year, which causes the ASC to start increasing. Thus, simple equations exist to compute economic lives and average system costs for various fleet replacement policies.

As already mentioned, current replacement policy is not a fleet replacement policy. Presently, some vehicles may be removed from the fleet because they are close to the replacement age and require repairs, the costs of which would exceed some repair expenditure limit (REL).

This policy will result in lowered average fleet costs. Improved REL's called Primary Repair Expenditure Limits (PREL) as in Reference 4 can be calculated from our estimation equations. First total system cost can be plotted as in Figure 6(d). Then a line drawn through the origin to the TSC curve which has the minimum slope, will be tangent to the TSC curve and will have slope equal to the minimum average system cost. The point of intersection will be the economic life. Fleet cost per year will be lower than under a group replacement policy if the distance between the tangent line and the TSC curve is set as the PREL for any age vehicle. This PREL requires that a current repair cost plus future expected repair cost averaged over the remaining time to the economic life will not exceed the minimum average system cost.

It is easy to analytically express the PREL for our particular model equation. The PREL is:

$$PREL(Y) = ACQ - (2 \cdot ACQ)^{1/2} \cdot a_1{}^{1/2} Y + \frac{a_1}{2} \cdot Y^2.$$

By making appropriate transformations the equation for PREL can be put in a simpler form based on percentage of economic life and percentage of acquisition cost. The simplified equation is merely:

$$PREL(X) = 1 - 2X + X^2.$$

Here, X is the percentage of economic life at the current age and the value of PREL(X) will be the maximum percentage of current acquisition cost that can be spent for a one time repair. It is also normal practice to limit any one time repair to fifty percent of current acquisition cost. Past experience has led to the conclusion that extremely expensive repairs are often unsatisfactory even after they have been made. A plot of the percentage PREL is given as Figure 7. This figure can easily be used to establish any required one time repair expenditure limit.

An example of the use of PREL follows. Assume vehicles of LIN N have a ten year economic life and a current acquisition cost of $5000. A six old vehicle of this type requires a major repair for which the estimated cost is $600. This vehicle is at sixty percent of its economic life, so the PREL can either be calculated or read from Figure 7. Calculation yields PREL(.6) = .16. Therefore, only sixteen percent of cost of a new vehicle should be spent for this repair. Thus, up to $800 may be spent for this repair and the work should be accomplished.

It should be noted that all the above discussion has been based on economic lives. An implicit assumption is that the same benefit can be derived from the vehicle at all times. It is quite possible that influence other than economic ones could lead to earlier replacement of vehicles than the economical policy suggests. An example would be critical safety hazards associated with older vehicles in terms of structural integrity. Other regulations such as fleet gasoline mileage standards might require old vehicle replacement. In any case, careful study will be required to determine if the service life of any vehicle should be set at the economic life or some lesser age.

The previous discussion has all been in terms of years. However, all the derivations can, of course, be performed in terms of mileage as well as years. Thus, results for economic lives in terms of mileage will be given without further discussion or explanation.

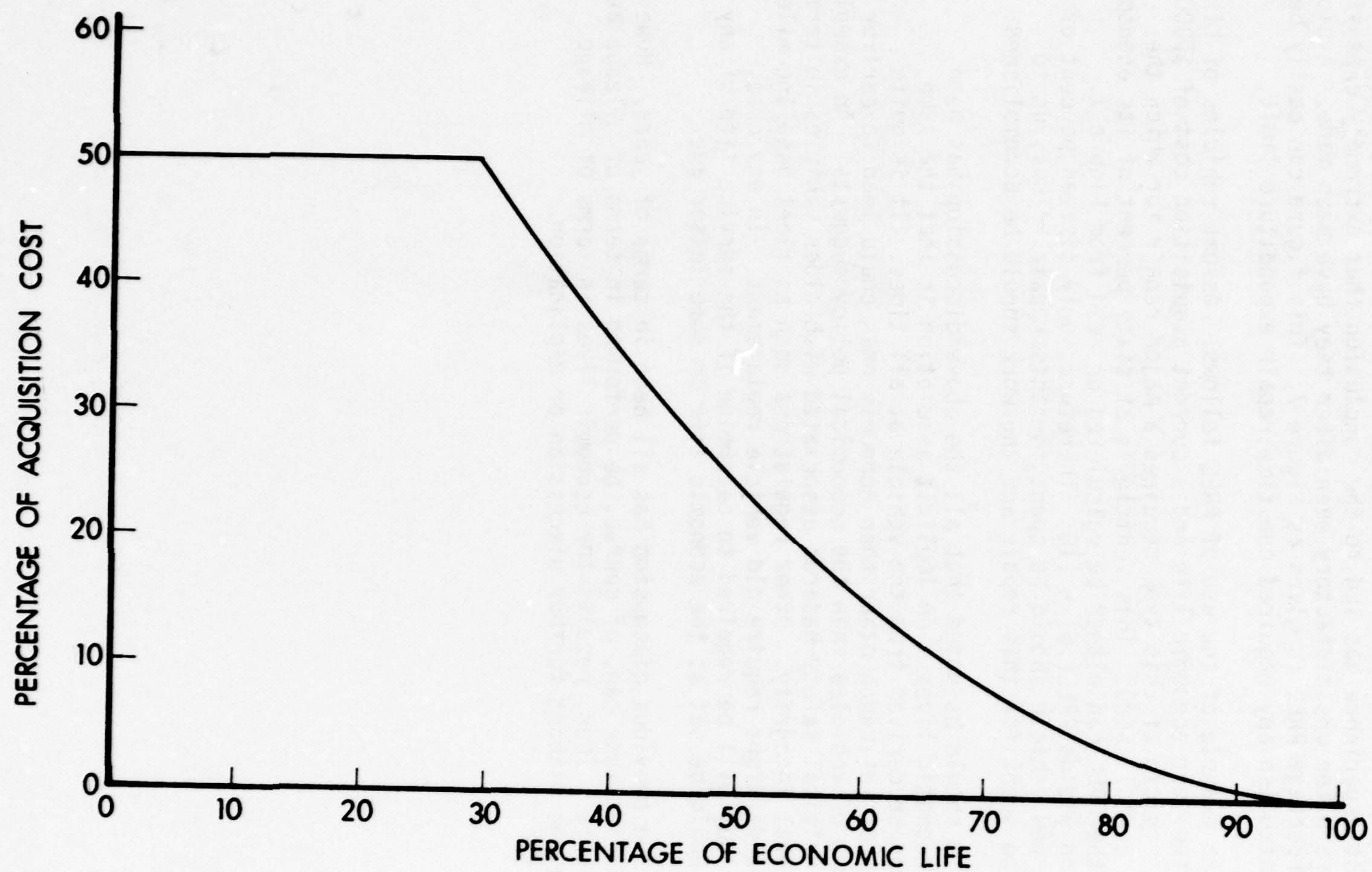

Figure 7. Percentage Primary Repair Expenditure Limit.

4. ANALYSIS RESULTS

4.1 General Results

Page plots and descriptive statistics were generated for all LIN's of vehicles represented in the data sources. Also, general model equations were fit to the data. After this preliminary analysis of the data only ten specific LIN's, of 86 originally examined, were determined to have enough vehicles with a representative mix of years and accumulated mileages for the analysis to proceed. Computer descriptive statistics or model fits are not provided for vehicle types not continued in the analysis. Attempts are being made to combine the 1977 and 1978 TRADOC data and/or to combine vehicle types with similar characteristics but different LIN's. No results from these analyses are available for this report.

For the ten LIN's continued in the study, the first runs of the model fits were examined. In all cases except the compact sedans, a downward quadratic was significant in the data. The later years where maintenance costs started dropping were removed from consideration in the model fitting procedure. he whole series of model fitting was reapplied. In all the new models, significantly increasing linear trends were observed and the downward quadratic trend was completely or mostly eliminated. These models were assumed to be the best predictors for costs and maintenance man-hours. Details on each of the studied LIN's is presented in Appendix B.

For each LIN type in the appendix, there are two years worth of data: TRADOC 1977 and 1978. For each LIN and year data, there is a cover sheet and seven graphs. The cover sheet contains the vehicle type LIN, nomenclature, acquisition cost, average annual mileage and information on the models' fits. Models are given for instantaneous maintenance cost in years and miles and for instantaneous maintenance man-hours in years. The estimated coefficients used in these equations are all statistically different from zero at the .95 significance level. Also, the residual standard deviation (RSD) is given for each model. The size of the RSD indicates how well the model predicts the behavior of individual vehicles for the characteristic being modeled. It is quite possible to have a very good average fit which may not be a good predictor for individual points. For the instantaneous maintenance cost curves, the value of the variable that minimizes the average system cost is given, as well as the minimum average system cost for the group replacement policy. Finally, a few additional thoughts, comments or cautions on this particular LIN vehicle type are given.

Seven plots have been provided for each LIN type. These curves all have specific uses and can also be used to compare differences among LIN's and between the two years of data. A short explanation of each plot is provided in the following paragraphs.

The first plot is the number of vehicles involved in the study versus the age of the vehicle in years. Normally, the more vehicles available in a given age the better an estimate can be made of the cost and maintenance man-hours for that age.

The second plot is the average annual usage, in miles, for the vehicles of each age in the study. There are three points for each age. These points are: x for the mean, and ∇ and Δ for the 95 percent lower and upper confidence bounds, respectively. These bounds and all other bounds are based on the assumption of a normal distribution as discussed in Section 3.4, Descriptive Statistics. These annual usage values are important since costs and man-hours are directly related to usage. The declining yearly usage for older vehicles is often evident in these plots. The interaction between decreasing usage and increasing costs per mile are sometimes evident, as in the plots for the panel truck.

The third plot gives the average ending mileage and 95 percent confidence bounds on ending mileage for each age of the subject LIN. These plots show the relationship between age and mileage. What can be noted clearly in many cases is that the older vehicles are the low mileage vehicles.

The fourth plot is more complicated than the others, but it is also more interesting. The average cost per year and the 95 percent confidence limits are given for each age. The solid line is the instantaneous maintenance cost prediction, assuming that each age vehicle has the same average annual usage. The differences in the average annual usage among the years often explain why the predictions may not seem to fit the means properly. The dashed curve is the average annual system cost. These two curves intersect at the minimum of the average system cost as explained in Section 3.7, Calculus of Model Equations. The similarities of the cost curves for the 1977 and 1978 TRADOC data were surprising, but welcome in that they indicate consistency of the data from year to year.

The fifth plot is cost per mile versus mileage. The solid line is the instantaneous maintenance cost and the dashed curve is the average system cost curve. As explained above, the two curves intersect at the minimum average system cost.

The sixth plot is on maintenance man-hours. The distinct points are the mean and 95 percent confidence bounds on the average annual man-hours for each age. The straight line is the predicted average yearly maintenance man-hours, assuming all age vehicles accumulate the average annual mileage. The comments made about the fourth plot on the effects of deviations from the average annual mileage apply to this plot as well as to the fourth plot.

The last plot is shop days per year by age. These points are the mean and 95 percent confidence bounds on the mean of the number of shop days per vehicle by age. These points should be considered in determining service life, because it is possible that vehicle nonavailability might increase for older vehicles without greatly increasing the cost of maintenance. For example, it may be almost impossible to find required repair parts. The resulting increase in vehicle nonavailability would be a good reason to set a service life which is less than the economic life. No attempt was made to fit nonavailability or shop days since the data were clearly not normally distributed. Most vehicles had few shop days, but a significant number had a surprisingly large number of shop days. For this same reason, the confidence limits in this case have less statistical validity than the other characteristics and should only be regarded as gross measures of data variability.

For almost all LIN's there are two sets of plots corresponding to the 1977 and 1978 TRADOC data. However, for LIN X39598, Truck Cargo 1/2 ton, it was necessary to split the data into three sets for each year of data. This split was necessary because of data handling limitations with some packaged programs used in performing the regression analyses. These sets were systematically extracted from the data by taking every third vehicle for one set, etc. Thus, there are six distinct estimates of the life for this particular LIN,which provides a very good check on the repeatability of the study results. The next section will show how surprisingly close these estimates turned out.

4.2 Economic Useful Lives in Years - Table 2 summarizes the information on the lives determined for each LIN for the two years of data available. Also, this table lists the presently established DOD lives of these vehicles for comparison and the vehicle replacement costs as provided by TARCOM. For each of the lives, the estimate of average system cost at that age is given. The change in average system cost (ΔASC) gives an indication of the yearly average savings that would result from a change in life policy, if all vehicles were replaced only at the specified life and if the fitted equations exactly predicted the average costs. It is not possible with the current methodology to predict the effect of either the present or PREL of this report on the average yearly system cost, therefore actual cost estimates cannot be presented. As noted in the table, only two LIN's, BØ4441, Auto Sedan Compact, and X39893, Truck Cargo 1 ton, do not have increased lives indicated by this analysis. Also of interest is the similarity of the estimates obtained with the 1977 and 1978 data. By examining the average system cost curves in Appendix B, it can be observed that these curves are very flat in the region of the minimum. Therefore, it was expected that small differences in the slope of the instantaneous cost curve would produce large changes in economic life, but results were quite close.

TABLE 2. ECONOMIC LIFE IN TERMS OF YEARS

Nomenclature	LIN	Replacement Cost ($)	DODI Life (Years)	ASC for DODI Life ($)	Estimated Life (Years)	ASC for Est. Life ($)	Change in Life (Years)	Δ ASC ($)	Data Source
Auto Sdn Cpt	B04441	3500	6	1027	6.8	1019	+ .8	8	TRADOC 78
"	"	"	"	1027	5.6	984	-+ .4	43	TRADOC 77
Trk Cgo 1/2 T	X39598	4539	6	958	12.8	745	+ 6.8	213	TRADOC 78
"	"	"	"	976	14.8	679	+ 8.8	297	"
"	"	"	"	956	14.6	693	+ 8.6	263	"
"	"	"	"	938	12.6	731	+ 6.6	207	TRADOC 77
"	"	"	"	951	13.7	711	+ 7.7	240	"
"	"	"	"	934	13.3	705	+ 7.3	229	"
Trk Cgo 1 T	X39893	6330	7	1660	7.3	1658	+ .3	2	TRADOC 78
"	"	"	"	1730	7.2	1702	+ .2	28	TRADOC 77
Trk Ca 1/2 T	X42064	5771	6	1057	13.9	896	+ 7.9	161	TRADOC 78
"	"	"	"	1197	13.0	918	+ 7.0	279	TRADOC 77
Trk Pnl 1/2 T	X54805	4501	6	957	12.2	763	+ 6.2	194	TRADOC 78
"	"	"	"	972	12.9	759	+ 6.9	213	TRADOC 77
Trk Stk 1 T	X56038	5214	7	1078	9.2	1035	+ 2.2	43	TRADOC 78
"	"	"	"	1122	8.9	1088	+ 1.9	34	TRADOC 77
Trk Stk 5 T	X56483	7650	10	1238	19.8	1050	+ 9.8	188	TRADOC 78
"	"	"	"	1264	20.2	1069	+10.2	195	TRADOC 77
Trk Tctr 28000	X60185	18,422	10	2235	28.1	1471	+18.1	764	TRADOC 78
"	"	"	"	2375	19.0	1963	+ 9.0	412	TRADOC 77
Trk Ulty 4X2	X61518	4253	6	929	9.0	849	+ 3.0	80	TRADOC 78
"	"	"	"	944	9.0	866	+ 3.0	78	TRADOC 77
Trk Ulty 4X4	X61655	5401	6	1238	12.5	995	+ 6.5	243	TRADOC 78
"	"	"	"	1153	8.7	1065	+ 3.7	88	TRADOC 77

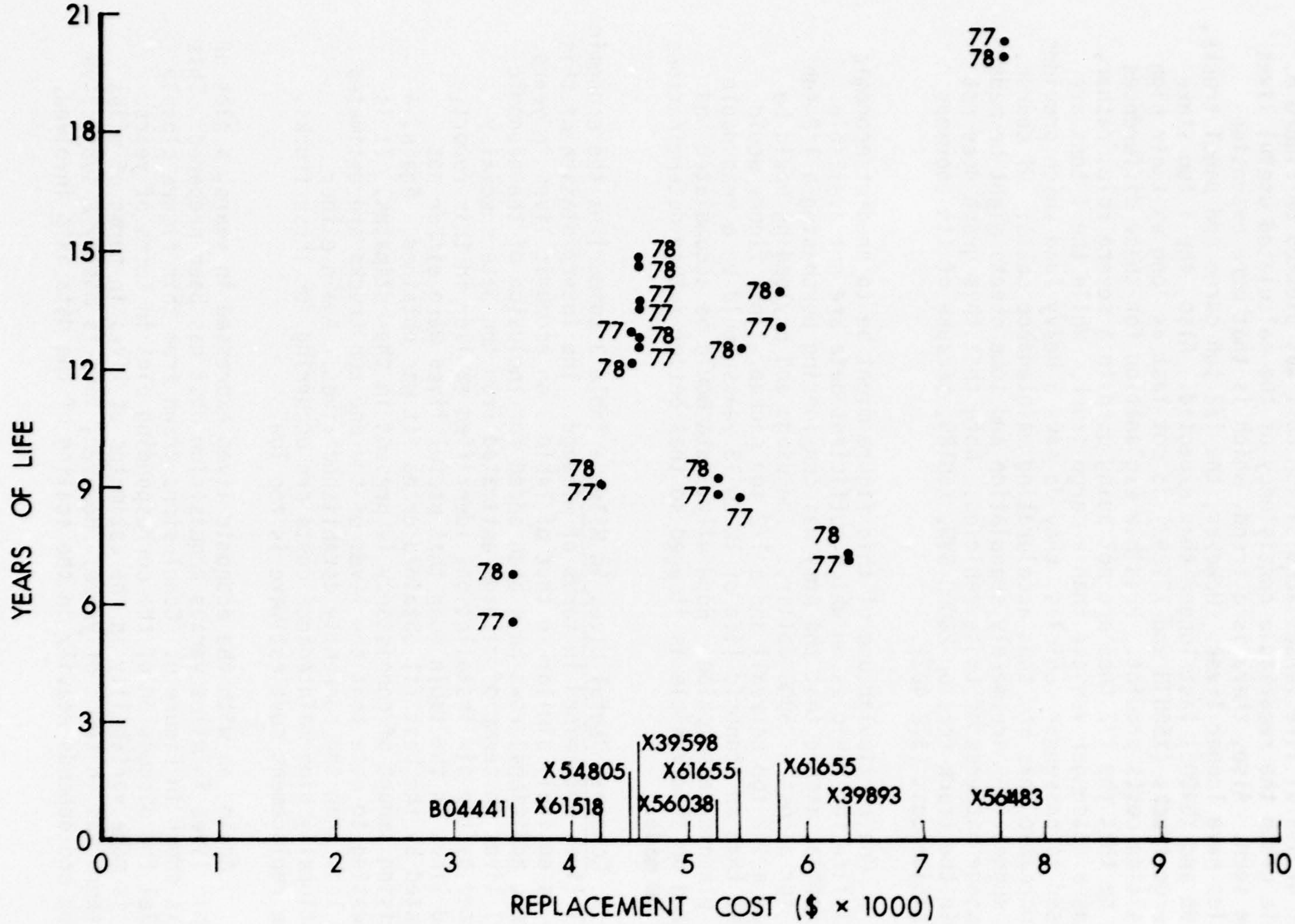

Figure 8. Comparisons of Economic Life in Years and Replacement Cost.

In order to visually examine the estimated economic useful lives, a plot of useful life versus acquisition cost was plotted on Figure 8. On this graph the remarkable consistency of the calculated useful lives can be seen. Also, there is a trend, which is that more expensive vehicles have longer lives. However, the 1/2 ton cargo and panel trucks, (X39598 and X54805) last longer than expected. Also, the 1 ton stake and cargo trucks (X56038 and X39893) do not last as long as their high acquisition costs predict. Possible explanation for these differences might be that the 1/2 tons are not being used in a severe role, rather, more as a passenger vehicle than a cargo truck. While the 1 tons are not used as passenger vehicles, they do have a heavy load which provides for increased wear and thus accelerating maintenance costs. Of course, these suggestions are merely speculation and some checks might be made into usage patterns of these vehicles. Note that this graph does not contain the truck tractor 28000 GVW, X60185, because of its enormous acquisition cost ($18,422).

One particular use of this figure might be to predict economic useful life for vehicles on which sufficient data are not available. For example, assume that the Army was considering purchasing a 1/2 ton truck for a cost of 5000 dollars. The usage and payloading would be between a 1/2 ton carryall and a 1/2 ton pickup. This figure would suggest that an economic life of 12 to 13 years would be a reasonable first planning assumption. Hopefully, data would be accumulated and analyzed on this vehicle as it aged so that better future determinations could be made.

4.3 Economic Useful Lives in Miles - Table 3 summarizes the economic useful lives determined in terms of mileage. The interpretation of this table is entirely similar to that of Table 2 on economic lives in years. However, additional rows have been added for inclusion of the economic useful lives in terms of mileage estimated from the data specially reported by the six installations identified earlier in this report. Dashed lines in the table mean that useful lives were either not indicated by the best fit obtained or no fit was obtained. Again, a surprising amount of consistency is present in the estimates. It is interesting to note that the lives of the one ton trucks are estimated to be less than the currently established lives. Again either exceptionally high maintenance costs are occurring for these trucks, or the replacement cost estimate is too low.

Again, as with the economic lives expressed in years, a plot of economic lives in miles versus acquisition cost has been prepared. This plot is shown in Figure 9. Conclusions drawn from this figure closely parallel the discussion of the corresponding plot in terms of years. There is more variability in the estimates of lives in terms of miles than there was in terms of years. However, this is mostly a subjective feeling and depends heavily on the scaling of the data axis involved.

TABLE 3. ECONOMIC LIFE IN TERMS OF MILEAGE

Nomenclature	LIN	Replacement Cost ($)	DODI Life (miles x 1000)	ASC for DODI Life (¢ per mile)	Estimated Life (miles x 1000)	ASC for Est. Life (¢ per mile)	Change in Life (miles x 1000)	Δ ASC (¢ per mile)	Data Source
Auto Sdn Cpt	B04441	3500	72	11.0	107	8.0	+35	3.0	TRADOC 78
"	"	"	"	10.1	82	9.7	+10	0.4	TRADOC 77
"	"	"	"	10.2	78	10.0	+ 6	0.2	Special *
Trk Cgo ½ T	X39598	4539	72	10.0	123	9.0	+51	1.0	TRADOC 78
"	"	"	"	10.0	164	8.0	+92	2.0	TRADOC 78
"	"	"	"	9.7	157	7.8	+85	1.9	TRADOC 78
"	"	"	"	9.7	135	8.3	+63	1.4	TRADOC 77
"	"	"	"	9.7	145	8.1	+73	1.6	TRADOC 77
"	"	"	"	9.6	136	8.2	+64	1.4	TRADOC 77
"	"	"	"	10.8	167	8.2	+95	2.6	Special *
Trk Cgo 1 T	X39893	6330	84	22.6	78	22.6	- 6	0.0	TRADOC 78
"	"	"	"	20.9	76	20.8	- 8	0.1	TRADOC 77
Trk Ca ½ T	X42064	5771	72	10.9	173	8.2	+101	2.7	TRADOC 78
"	"	"	"	10.9	150	8.7	+78	2.2	TRADOC 77
"	"	"	"	12.5	119	11.0	+47	1.5	Special *
Trk Pnl ½ T	X54805	4501	72	11.3	128	10.0	+56	1.3	TRADOC 78
"	"	"	"	10.7	146	9.1	+74	1.6	TRADOC 77
Trk Stk 1 T	X56038	5214	84	16.4	80	16.4	- 4	0.0	TRADOC 78
"	"	"	"	15.8	80	15.8	- 4	0.0	TRADOC 77
"	"	"	"	17.0	79	17.0	- 5	0.0	Special *
Trk Stk 5 T	X56483	7650	150	17.8	133	17.7	-17	0.1	TRADOC 78
"	"	"	"	18.8	159	18.8	+ 9	0.0	TRADOC 77
Trk Tctr 28000	X60185	18422	150	25.9	210	24.9	+60	1.0	TRADOC 78
"	"	"	"	21.8	179	21.4	+29	0.4	TRADOC 77
"	"	"	"	24.5	217	20.0	+67	4.5	Special *
Trk Ulty 4X2	X61518	4253	72	12.1	111	11.4	+39	0.7	TRADOC 78
Trk Ulty 4X4	X61655	5401	72	17.8	116	16.7	+44	1.1	TRADOC 78

*Data specifically provided by Forts Benning, Knox, Lewis and Schafter, White Sands Missile Range and Aberdeen Proving Ground.

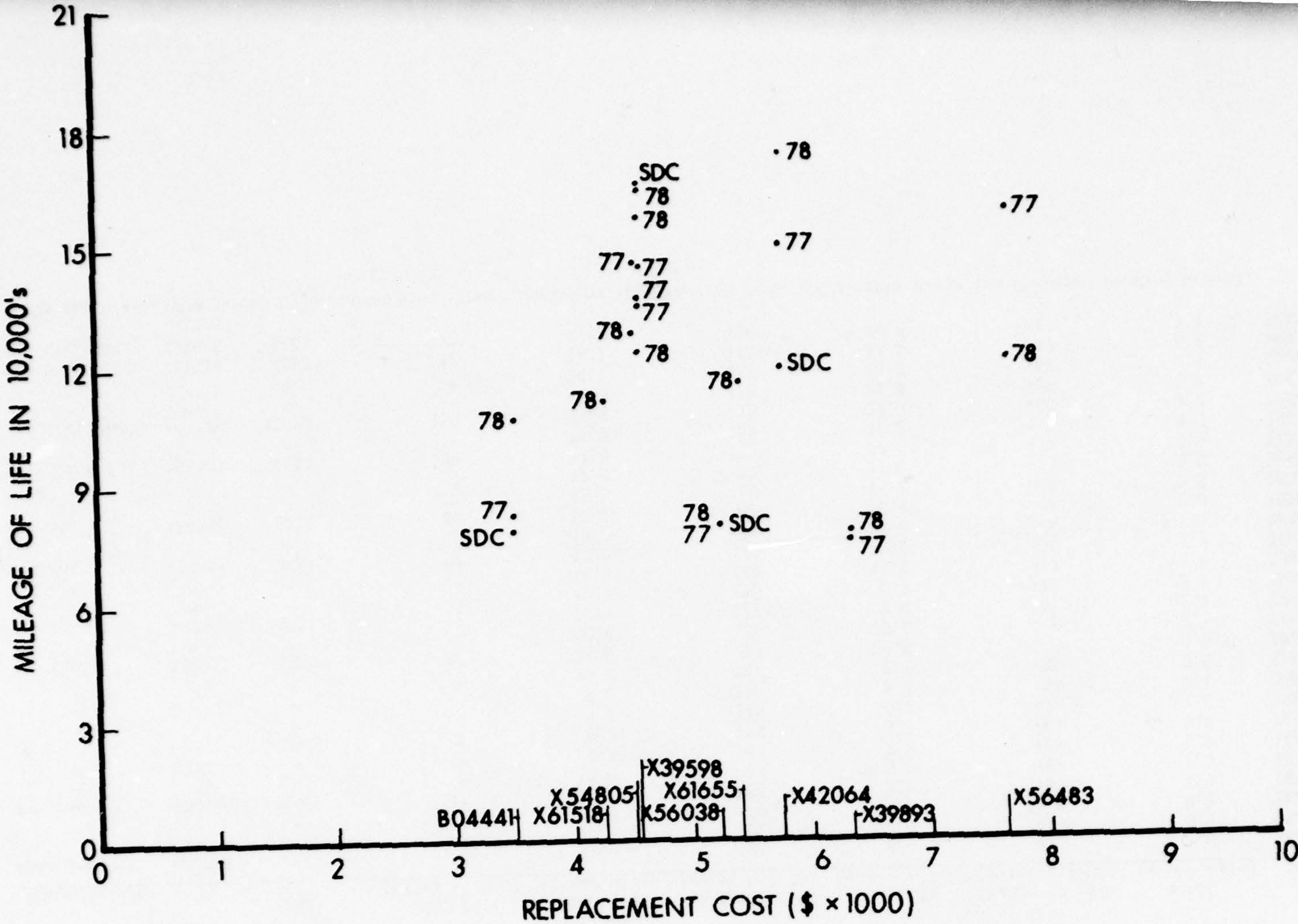

Figure 9. Comparison of Economic Life in Miles and Replacement Cost.

4.4 Maintenance Man-hour Predictions - The direct maintenance man-hour estimates for each LIN are given in Table 4. These estimates also demonstrate good consistency from 1977 to 1978. In order to make the best single predictions, the equations for each LIN have been averaged together and rounded off. These best estimates are given in Table 5.

As an example of the use of Table 5, assume that a transportation motor pool has 20 compact sedans that are 4 years old and that these sedans average 10,000 miles a year. One four year old sedan compact is expected to require 42 man-hours of maintenance at 13,000 miles a year. At 3000 fewer miles a year, a downward adjustment of 3 man-hours is made for the vehicle. Thus, any one vehicle is expected to have 39 hours of maintenance or all twenty will need a total of 780 man-hours of maintenance. Similar calculations would need to be performed for all vehicles in order to estimate total motor pool direct man-hour requirements. However, it was not possible to get estimates of man-hour requirements based on age for all LIN's. Work on additional LIN's is proceeding and overall averages could be obtained as a first estimate if required.

These maintenance man-hour requirements should be carefully reviewed before a decision is made to increase the service lives of a significant number of vehicles. It is probable that more maintenance man-hours would be required from current facilities than possible if the service lives of large numbers of vehicles are increased. This would result in decreased availability of vehicles and therefore less benefits. Another approach would be to expand facilities, but this would require a larger capital expenditure than that required to buy new vehicles. Therefore, the impact on maintenance facilities and manpower resulting from increasing service lives of vehicles should be carefully considered.

Figure 10 shows the graphs of the estimates of maintenance man-hours for all LIN's per 1000 miles of yearly usage. It should be remembered that these estimates were all based on a particular observed average annual usage. It is not expected that the relationship of direct maintenance man-hours to usage would be linear over the annual usage for the total ranges of usage. However, this graph is instructive. Note that the 1/2 ton trucks have the lowest maintenance man-hour requirements. Also, for all practical purposes, there is no difference between the 1/2 ton cargo or carryall trucks and only slightly higher man-hour requirements for the panel truck. The 5 ton trucks also exhibit similar maintenance man-hour characteristics. The compact sedan estimate has a surprisingly rapid increase in maintenance man-hours. The 1 ton cargo and stake trucks and the 1/2 ton utility trucks (4x4 and 4x2) show high requirements and rapid increases in the required direct maintenance man-hours.

TABLE 4. ESTIMATED DIRECT MAINTENANCE MAN-HOUR REQUIREMENTS

Nomenclature	LIN	DA Usage Objective (miles x 1000)	TM 38-600 Man-hour Adjustment Factor Per 1000 Miles	Estimated Usage (miles x 1000)	Man-hours per 1000 Miles in Age (Y)	Man-hour Adjustment Factor Per 1000 Miles	Data Source
Auto Sdn Cpt	B04441	3.6	2.0	13	4.48 + 9.54Y	1.4	TRADOC 78
"	"	"	"	10	-9.79 + 11.42Y	0.0	TRADOC 77
Trk Cgo ½ T	X39598	3.6	3.5	8	5.66 + 3.75Y	1.4	TRADOC 78
"	"	"	"	8	9.52 + 2.47Y	0.8	TRADOC 78
"	"	"	"	8	7.16 + 3.03Y	1.1	TRADOC 78
"	"	"	"	8	2.56 + 4.34Y	1.3	TRADOC 77
"	"	"	"	8	4.88 + 3.52Y	1.0	TRADOC 77
"	"	"	"	8	3.56 + 3.82Y	1.1	TRADOC 77
Trk Cgo 1 T	X39893	3.6	3.0	7	14.14Y	2.5	TRADOC 78
"	"	"	"	7.8	6.48 + 13.21Y	2.6	TRADOC 77
Trk Ca ½ T	X42064	3.6	3.5	11.0	6.04 + 4.38Y	0.9	TRADOC 78
"	"	"	"	10.0	5.61 + 4.32Y	0.7	TRADOC 77
Trk Pnl ½ T	X54805	3.6	3.5	6.7	4.1 + 4.33Y	0.6	TRADOC 78
"	"	"	"	7.0	5.6 + 4Y	0.8	TRADOC 77
Trk Stk 1 T	X56038	3.6	3.0	6.2	-5.8 + 8.66Y	1.5	TRADOC 78
"	"	"	"	6.6	-3.6 + 9.49Y	1.2	TRADOC 77
Trk Stk 5 T	X56483	5.0	10.0	6.0	20.95 + 3.09Y	3.3	TRADOC 78
"	"	"	"	5.4	20.92 + 3.45Y	3.6	TRADOC 77
Trk Tctr 28000	X60185	5.0	10.0	5.0	15.54 + 3.19Y	3.2	TRADOC 78
"	"	"	"	6.6	12.54 + 5.77Y	4.1	TRADOC 77
Trk Ulty 4X2	X61518	3.6	3.5	5.6	-.82 + 6.43Y	1.1	TRADOC 78
"	"	"	"	5.6	-4.34 + 7.5Y	0.0	TRADOC 77
Trk Ulty 4X4	X61655	3.6	3.5	4.7	8.04 + 5.96Y	2.2	TRADOC 78
"	"	"	"	5.3	-5.02 + 10.22Y	0.0	TRADOC 77

TABLE 5. BEST ESTIMATES OF MAINTENANCE MAN-HOURS REQUIREMENTS

Nomenclature	LIN	Annual Usage Miles x 1000	Man-Hours Per 1000 Miles in Age (Y)	Adjustment Man-Hours Per 1000 Miles
Auto Sdn Cpt		11.5	-.32 + .94Y	.7
Trk Cgo ½ T	X39598	8.0	.70 + .44Y	1.1
Trk Cgo 1 T	X39893	7.4	.42 + 1.86Y	2.5
Trk Ca ½ T	X42064	10.5	.55 + .41Y	0.8
Trk Pnl ½ T	X54805	6.9	.71 + .61Y	0.7
Trk Stk 1 T	X56038	6.4	-.75 + 1.42Y	1.4
Trk Stk 5 T	X56483	5.7	3.68 + .58Y	3.5
Trk Tctr 28000	X60185	5.8	2.49 + .76Y	3.7
Trk Ulty 4x2	X61518	5.6	-.47 + 1.25Y	0.6
Trk Ulty 4x4	X61655	5.0	.38 + 1.6Y	1.1

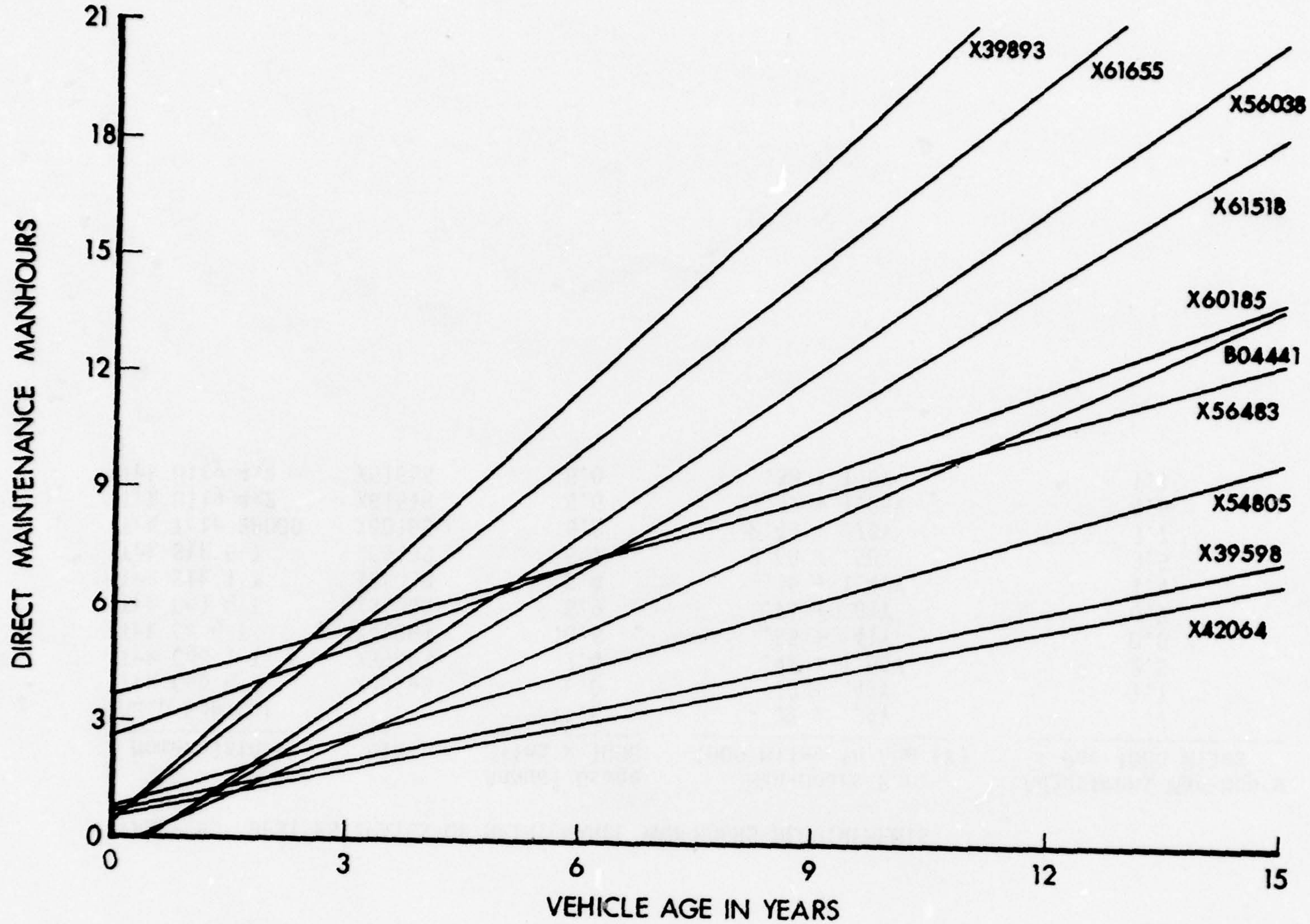

Figure 10. Direct Maintenance Manhour Requirements Per 1000 Miles.

In order to simplify Table 5 with respect to estimation of man-hours, several LIN's can probably be combined. These would be the 1/2 ton cargo and carryall trucks, the 5 ton stake and tractor trucks, and perhaps the 1 ton stake and cargo trucks. Further consideration needs to be given to the types of equations required for manpower staffing purposes at installation motor pools.

5. POSSIBLE IMPROVEMENTS

5.1 Current Study - As already noted, a sufficient data base existed to allow economic lives and maintenance man-hour standards to be estimated for only ten different LIN's. Work is continuing to combine the 1977 and 1978 TRADOC data bases. Once this merger is complete, several more LIN's should be candidates for a useful life determination. A different possibility would be to combine several LIN's for which vehicle characteristics are very similar. A quick review of the data plots reveals no good candidates for such combinations, but there may exist some suitable LIN's. A final possibility would be to continue the study with an additional year's data from TRADOC and, hopefully, FORSCOM. Combination of all the data then available should allow economic life determination for many more LIN's. In any case, analysis should continue, since the Army will probably be expected to develop economic life estimates for all AUV LIN's and other types of vehicles as well.

For those LIN's already studied, additional analysis could be performed. This work would primarily be in the areas of result sensitivity and statistical confidence. The effect of changes in acquisition costs or the estimates of instantaneous maintenance costs should be developed. The final aim would be to establish the amount of confidence in the economic lives which have been generated.

There are other possible improvements that might prove worthwhile to explore if time and resources are made available. One possibility is the inclusion of costs for vehicle nonavailability, indirect maintenance man-hours and materiel in the cost estimates, although none of these factors is expected to significantly alter the estimated useful lives. As already noted, the model equations developed in this study are not good individual vehicle cost predictors even though they are good average fleet cost predictors. It might be possible to develop a better predicting model by the incorporation of additional factors. Such factors might include: geographical location, vehicle manufacturer, use conditions, etc. For instance, there might be significant cost savings to the Army in retaining AUV's longer in the deserts of the Southwest than those in the snow and salt of the Northeast. Different manufacturers' vehicles may have different economic lives. The possibilities of improvements go on and on.

However, even if all these improvements were made, the type of methodology used in this report would still have a basic fault. The whole approach is based on a group replacement policy at a given age and mileage. It is possible to show that fleet costs can be reduced by use of other replacement policies, such as the primary repair expenditure limits discussed earlier in this report. However, no predictions are available for the fleet costs under the primary repair expenditure limits policy. There is also no way to predict the number of replacement vehicles that would be required because of vehicles exceeding the limits in any one year. The two items of policy costs and vehicle replacements required are necessary for planning purposes.

5.2 Improved Approach - It is worthwhile to consider the type of study that would be needed for planning purposes. First, the methodology should provide the optimal policy for vehicle replacement. Secondly, all important quantities should be estimable for the optimal policy. These estimates would be fleet cost, man-hour requirements and vehicle replacements. A third feature would be the ability to evaluate alternative policies. It is entirely possible that the optimum policy might not be followed because of new vehicle capital expenditure restraints. These restraints would require changes in vehicle replacements available and thus have an impact on fleet maintenance costs and manpower requirements. Finally, the methodology should be usable to determine how to proceed from the current fleet status to approach the optimal fleet status. In fact, the groundwork for such methodology has been developed.

A special study group of the British Army was set up at the Royal Electric and Mechanical Engineers Data Center in the early 1970's. This group spent considerable time on the problem of vehicle replacements. Their approach develops estimates of the distributions for the number of repair visits and the costs of these bisits based on the age of the vehicle. Once these distributions are estimated a statistical model and optimizing routines can be applied. Using the statistical model, basic factors such as fleet cost, maintenance man-hours and vehicle replacements can be estimated for any repair policy. The optimizing routines estimate the optimal replacement policy. Currently, this Activity does not have sufficient information to conveniently implement this methodology, which is documented in Reference 6, on Repair Limit Replacement Methods. Efforts are in progress to obtain additional details from the British.

This improved approach has an additional benefit. Once basic distribution shapes are known, it generally takes less data to estimate the distribution parameters than it takes to actually have data on costs or man-hours under many different conditions and then attempt to use linear regression as an estimator. Thus, it would be easier to study factors such as geographical location or manufacturer differences than with the methodology used in this study.

6. CONCLUSIONS

6.1 Vehicle Lives - The results of this study indicate that the economic lives of some vehicles can be extended from their current established lives. While considerable cost savings are indicated in some cases, there is some risk involved in making large increases in vehicle lives. These are: that the predictions for maintenance cost might not hold, that vehicle availability might fall because of a lack of parts supply and that the vehicles may suddenly collapse due to corrosion or fatigue. Therefore, it is thought to be prudent to pick the lowest estimated economic lives of Tables 2 and 3 as the new economic lives. These lives are given in Table 6. The impact of any changes in lives on maintenance support should be evaluated before any policy changes are adopted. The maintenance burdens caused by increasing the vehicle lives may not be supportable. Also, studies such as this should be continued to determine if projections of maintenance costs were valid.

TABLE 6. RECOMMENDED ECONOMIC LIVES

Nomenclature	LIN	Economic Lives Age In Years	Economic Lives Age In Mileage (x 1000)
Auto Sdn Cpt	B04441	6	80
Trk Cgo ½ T	X39598	13	120
Trk Cgo 1 T	X39893	7	75
Trk Ca ½ T	X42064	13	120
Trk Pnl ½ T	X54805	12	120
Trk Stk 1 T	X56038	9	80
Trk Stk 5 T	X56483	20	130
Trk Tctr 28000 GVW	X60185	20	175
Trk Ulty 4x2	X61518	9	110
Trk Ulty 4x4	X61655	9	115

6.2 Repair Expenditure Limits - With the increased vehicle lives in Table 6, it is even more important that an effective repair expenditure limit policy be adopted. There will be more major repairs required on older vehicles and many of these repairs will be uneconomical to complete. The best repair expenditure limit that can be derived from the current methodology and data is explained in Section 3.7. Thus, the percentage repair expenditure limits of Figure 7 should be adopted as policy if vehicle lives are extended. However, adoption of any repair expenditure limit replacement policy presents a problem, since current methodology does not provide an estimate of vehicle replacements required when a repair expenditure limits policy is in force. Therefore, it is recommended that further studies be undertaken which would allow replacement requirements to be estimated.

6.3 Maintenance Man-hour Standards - The results of this study indicate significant changes in maintenance man-hour requirements based on a vehicle's age. The recommended estimates for maintenance man-hour requirements are given as Table 7. These estimates are for a year's maintenance for vehicles of any particular age, Y, at the average annual mileage for that type vehicle. An adjustment is provided for use in areas where the average annual mileage is above or below that for the fleet. One problem should be noted for these estimates. These equations assume that all required maintenance for a vehicle will be performed regardless of vehicle age. These estimates will be high for older vehicles on which repairs may not be performed because of the repair expenditure limits. It is again recommended that a procedure be developed for determining how many vehicles of a particular age will be determined non-economically repairable because of the repair expenditure limits.

TABLE 7. RECOMMENDED MAINTENANCE MAN-HOUR ESTIMATES

Nomenclature	LIN	Annual Usage Miles x 1000	Man-hours Per Year by Age(Y)	Adjustment Man-hours Per 1000 Miles From Annual Average
Auto Sdn Cpt	B04441	11.5	-3.68 + 10.81Y	.7
Trk Cgo ½ T	X39598	8.0	5.60 + 3.52Y	1.1
Trk Cgo 1 T	X39893	7.4	3.11 + 13.76Y	2.5
Trk Ca ½ T	X42064	10.5	5.78 + 4.31Y	0.8
Trk Pnl ½ T	X54805	6.9	4.90 + 4.21Y	0.7
Trk Stk 1 T	X56038	6.4	-4.80 + 9.09Y	1.4
Trk Stk 5 T	X56483	5.7	20.98 + 3.31Y	3.5
Trk Tctr 28000	X60185	5.8	14.20 + 4.41Y	3.7
Trk Ulty 4x2	X61518	5.6	-2.63 + 7.00Y	0.6
Trk Ulty 4x4	X61655	5.0	1.90 + 8.00Y	1.1

6.4 Policy Changes - In each of the three previous conclusion sections, it was necessary to include cautions on the limitations of this study methodology. In each case, further study was recommended. However, if past history is any indicator, it may be another 15 years before AUV lives are again addressed. The reason for this lack of attention is clearly stated in the report entitled, "Policies to Reappraise Economic/Useful Life," by the Logistics Study Office of the DARCOM Army Logistics Management Center, Reference 7. Their study points out that there are no Army regulations setting requirements or responsibilities for the conduct of economic useful life analyses. The topic of equipment lives is seldom raised until budget money becomes difficult to obtain. This fact is regrettable because the Army has a considerable investment in its AUV fleet. It is recommended that some agency be given the responsibility and resources necessary to effectively attack the vehicle economic life problem. It is anticipated that the cost benefits of such a commitment can be easily proven.

A problem encountered in the development of this study was that each major Army command can develop its own AUV data management system. This policy has led to separate systems, some of which cannot readily be used for new studies since they were developed only to provide required summary data. Even when the proper data are available, contact with many agencies is required to actually obtain the data. Whatever agency is given the economic analysis responsibility should be given the authority to require that basic maintenance data be reported in a standard format to some central data base for analysis.

REFERENCES

1. DODI 4150.4, "Replacement and Repair Guidance, and Life Expectancies for Commercial Type Vehicles," 5 April 1963.

2. DODI 4151.10, "Maintenance Man-hour Input Standards for Commercial (Transport) Design Motor Vehicles," 27 December 1963.

3. AR 58-18, "Administrative Motor Services Cost and Performance"

4. "An Economic Replacement Model," Drinkwater, R.W., and Hastings, N. A. J., Operations Research Quarterly, Volume 18, No. 2.

5. TM 38-600, "Administrative Use Vehicle Management," 10 May 1966.

6. Note No. 68, 41-202, "Description of the Development Work on the Repair Limit Replacement Method Undertaken by the REME Data Centre from 1971 to 1974," Mahon, Major B. H., and Bailey, R. J. M.

7. Logistics Studies Office, Project No. 803, "Policies to Reappraise Economic/Useful Life," U S Army Logistics Management Center, January 1979.

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APPENDIX A

CORRESPONDENCE

DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR LOGISTICS
WASHINGTON, D.C. 20310

S-31 May 1977
01 DEC 1976

DALO-TSM-P

SUBJECT: Life Expectancy Years and Miles for Commercial Design Vehicles

Commander
US Army Materiel Development
and Readiness Command
ATTN: DRCMM
5001 Eisenhower Avenue
Alexandria, VA 22333

1. DA has received numerous inquiries concerning the validity of the current life expectancy in years and miles for commercial design vehicles. Improvements in automotive engineering and technology have generally led toward longer life expectancy.

2. Current DOD life expectancy years and miles criteria are contained in DODI 4150.4, Inclosure 1. DA implementation criteria are contained in Table 2-1, AR 700-88, Inclosure 2.

3. In order to recommend necessary changes to DOD, request a study be conducted to determine appropriate current life expectancy years and miles for commercial design vehicles. It is the understanding of this office that the commercial vehicle manager at TARCOM has a similar study in progress which may provide the necessary information.

4. Request results of the study, to include recommended changes to the life expectancy years and miles, be furnished to this office NLT 31 May 1977.

FOR THE DEPUTY CHIEF OF STAFF FOR LOGISTICS:

2 Incl
as

LELAND F. TIGH, JR.
Colonel, GS
Chief, Strategic Mobility
and Policy Division

NUMBER 4150.4
DATE April 5, 1963
ASD(I&L)

Department of Defense Instruction

SUBJECT Replacement and Repair Guidance, and Life Expectancies for Commercial Design Vehicles

Reference: (a) DoD Instruction 4150.4, "Repair Limits and Life Expectancies for Commercial Type Vehicles," April 6, 1955 (hereby cancelled)

I. PURPOSE AND OBJECTIVE

A. This Instruction establishes uniform policies and guidance governing expenditure of funds for maintenance and repairs, and for replacement of commercial design vehicles used by the Department of Defense, giving due consideration to the age, mileage and cost of repair.

B. Its objective is to provide the military with a dependable transportation posture by (1) maintaining DoD-owned commercial design vehicles to the maximum economical life expectancy with maintenance manpower input standards uniformly applied, and (2) replacing each vehicle at the period when expensive repairs are needed. This plan will assure dependable operations and operation at the lowest cost-per-mile average.

II. APPLICABILITY

The provisions of this Instruction apply to all components of the DoD assigned responsibility for the management of Government-owned commercial design vehicles.

III. BACKGROUND

A. The Department of Defense now operates many thousands of commercial design vehicles to meet a variety of military requirements. The use of commercial design vehicles is more economical from the standpoint of initial investment and operating cost when compared with the alternative of using tactical ("M" series) vehicles. In many cases these investment and operating economies are being offset by high maintenance expenditures for repairs required by uneconomically repairable vehicles because no replacement vehicles are available.

B. This Instruction is designed to improve the readiness posture of the commercial fleet through incremental procurement of replacement vehicles and immediate replacement of uneconomically repairable vehicles. This should result in an improved basis for annual planning and reduced maintenance workloads which together are expected to reduce maintenance expenditures.

IV. DEFINITIONS

For purposes of this Instruction, the following definitions apply:

A. Commercial design vehicle: An engine or motor-driven vehicle designed to meet civilian requirements and intended for general use in the transportation of personnel, equipment, supplies, and/or other cargo. This will include the complete chassis of a commercial design vehicle on which special equipment may be mounted in lieu of a commercial type body.

B. Extensive repair: A one-time repair, including repair resulting from accident, which costs more than 10% of the purchase price and less than 50% of current wholesale value of the vehicle as determined in accordance with paragraph IV, G. and H.

C. Uneconomical repair: Any estimated one-time repair which is 50% or more of current wholesale value of the vehicle.

D. Minor repairs: Repairs and preventive maintenance performed by drivers and repairs for which "work orders" are not issued.

E. Age: Starts from the initial date of delivery to military supply.

F. Mileage: Miles operated to date or expected mileage over the life of the vehicle (as tabulated in Table I).

G. Current Wholesale Value of Vehicle: At any one point in time, values of used vehicles vary as between localities. Accordingly, local determinations should be made in establishing the value for each vehicle under consideration. Such determinations should be based on the regional wholesale prices provided by commercial publication for this purpose, adjusted to meet local conditions as determined from the trade.

H. Projected Wholesale Value of Vehicle: The wholesale value at the end of the life expectancy of a particular vehicle should be determined by comparing the vehicle with an earlier model of the same type, consistent with Table I. For example: the projected wholesale value of a 3 year old sedan 3 years hence should be stated as the current wholesale price of a like 6 year old sedan, determined in accordance with IV. G. above.

V. POLICY

A. Commercial (passenger and transport) design vehicles will be used wherever practical under logistic and strategic guidance. The size of the fleet will be the minimum required to provide essential needs.

B. Commercial vehicles will be maintained in a safe, serviceable condition and in acceptable appearance throughout their service life with the minimum annual expenditures.

C. Commercial vehicles will be replaced and disposed of in accordance with the age and mileage criteria furnished in Table I (Inclosure 1 hereto).

D. Provisions will be made for the immediate replacement of any commercial design vehicle that has not reached the age or mileage shown in Inclosure 1 when estimated "repair expenditure" for future mileage adjusted average cost is greater than that of a new vehicle, providing there is still a valid requirement for a vehicle of this type. Replacement decisions are concerned only with the future value; neither the equipments' original cost nor the vehicle's past maintenance cost is a controlling factor. The future mileage adjusted average cost will be determined by use of the formula included in paragraph VI.E.

E. Whenever it is determined that a vehicle should be replaced in accordance with the criteria established by this instruction and a replacement vehicle is not currently available, the vehicle in question may be provided minimum repairs, sufficient to insure safe operations, and continued in use on a temporary basis, pending replacement of the vehicle.

VI. PROCEDURES

Determinations of economic feasibility for repairs or replacement of commercial design vehicles will be based on the following:

A. Prior to starting repair work a preliminary inspection will be made and a cost estimate prepared for each commercial design vehicle sent to the maintenance shop. Estimates are not required for minor maintenance repairs.

B. A uniform estimating procedure (with a standard labor and overhead rate) will be used in preparing all repair estimates. Labor hour estimates will be based on approved commercial (when available) or military flat rate time standards. Estimated repair costs will be computed by multiplying labor hours by $5.00 rate and adding cost of required materiel. These cost estimates for commercial vehicles will include the price of parts required in the repair operation, or the exchange charge for complete assemblies and sub-assemblies installed.

C. Repair costs, except those resulting from accidents, will not include the replacement of tires, batteries, tools, chains, anti-freeze, seat covers and winches, or any repair performed on special equipment which may be mounted on a commercial design vehicle chassis.

D. Whenever estimated repair cost is greater than 50% of the current wholesale value of a vehicle of the same age and type as determined in accordance with paragraph IV.G. the vehicle will not be repaired since this would be considered an uneconomical repair. Under these circumstances, prompt action will be taken to effect replacement of the vehicle.

E. The following formula will be used to determine if extensive repair work will be performed or the vehicle replaced:

a. Repair when $\frac{p + r - s}{m - o}$ is less than $\frac{c + t - s}{m}$

b. Otherwise request replacement of vehicle.

Legend

c = Current cost of like vehicle.
t = Additional transportation cost (not included in c), plus costs of preparation for operation.
r = Estimated cost of repair (computed in accordance with Paragraph VI.B).
s = Projected wholesale value at end of life (use years per Table I).

- p = Present value, (current wholesale value) "as is" before repairs.
- m = Miles - life expectancy (Table I).
- o = Miles operated to date.

VII. IMPLEMENTATION

The Military Departments will implement this directive in 90 days. Two copies of implementing instructions or revisions to existing instructions will be submitted to the Assistant Secretary of Defense (Installations and Logistics).

VIII. EFFECTIVE DATE

This Instruction is effective 1 July 1963.

Thomas D. Morris
Assistant Secretary of Defense
(Installations and Logistics)

1 Attachment:
Table of Life Expectancies

TABLE I

COMMERCIAL VEHICLES
Life Expectancy Years and Miles*

Description	Years	Miles
Ambulance, All	8	60,000
Sedans, All	6	72,000
Station Wagon	6	72, 000
Bus, Body on Chassis (BOC) (up to 37 passengers)	8	84,000
Bus, Body on Chassis (over 37 passengers)	10	150,000
Bus, Integral	12	300,000
Truck 1/4 thru 3/4 ton (under 7,000 GVW)	6	72,000
Truck and Truck Tractor 1 thru 2 ton (7,000 thru 18,999 GVW)	7	84,000
Truck and Truck Tractor 2 1/2 thru 4 ton (19,000 thru 23,999 GVW)	8	84,000
Truck and Truck Tractor 5 thru 10 ton (24,000 thru 39,999 GVW)	10	150,000
Truck and Truck Tractor 11 ton and over (40,000 GVW and up)	12	300,000
Trailers and Semi Trailers	15	--
Motorcycle	3	15,000
Scooter 3W - Package Del	3	9,000

*Years or miles indicated whichever occurs first.

Table 2-1. Commercial Design Vehicles

Life Expectancy Years and Miles [1]

Description	*Years*	*Miles*
Ambulance, All	8	60,000
Sedans, All	6	72,000
Station Wagon	6	72,000
Bus, Body on Chassis (up to 37 passengers)[2]	8	84,000
Bus, Body on Chassis (over 37 adult passengers)	10	150,000
Bus, Integral [3]	12	300,000
Truck under 7,000 GVW	6	72,000
Truck and Truck Tractor 7,000 thru 18,999 GVW	7	84,000
Truck and Truck Tractor 19,000 thru 23,999 GVW [4]	8	84,000
Truck and Truck Tractor 24,000 thru 39,999 GVW	10	150,000
Truck and Truck Tractor 11 ton and over (40,000 GVW and up)	12	300,000
Trailers and Semitrailers	15	--------
Motorcycle	5	30,000
Scooter 3W—Package Del	5	15,000

[1] Years or miles indicated, whichever occurs first.
[2] Includes Bus, 60 Passenger, School Age.
[3] Limited to Suburban and Interstate Types only.
[4] 300,000 miles for all Diesel-engine driven equipment in this GVW class.

DRSTA-MSA (1 Dec 76) 2d Ind
SUBJECT: Life Expectancy Years and Miles for Commercial Design Vehicles

HQ, US Army Tank-Automotive Materiel Readiness Command, Warren, MI 48090 17 JAN 1977

TO: Commander, US Army Materiel Development and Readiness Command, ATTN: DRCMM-MS, Alexandria, VA 22333

1. Reference:

a. FONECON between Mr. Raymond Bell (AMSAA) and Mr. Henry Martin (DRSTA-MSA) on 4 January 1977.

b. FONECON between Captain Hughes (DRCMM-MS) and Mr. Don Swartz (DRSTA-MSA) on 5 January 1977.

2. In response to the statement made by DA regarding a study being performed by TARCOM, we have found that the study will not provide the information sought. Also, AMSAA is performing an Average Useful Life Study for the M880; however, this study will not provide the requirements.

3. During referenced conversation (1a), the length of time to perform such a study as requested by DA was discussed. Mr. Bell believes that a meeting should be scheduled with DARCOM, TARCOM and AMSAA representatives in attendance to discuss such an undertaking.

4. Request a meeting be scheduled at DARCOM in order that a study plan and milestones can be developed. Point of contact at TARCOM is Mr. Henry Martin, AUTOVON 369-2885/2951.

FOR THE COMMANDER:

M. M. CIESLAK
Deputy Director
Maintenance Dir (NMP)

wd all incl

9 DEC 1976

DRCMM-MS (1 Dec 76) 1st Ind
SUBJECT: Life Expectancy Years and Miles for Commercial Design Vehicles

HQ, US Army Materiel Development and Readiness Command, Alexandria, VA 22333

TO: Commander, US Army Tank-Automotive Materiel Readiness Command, ATTN: DRSTA-M, Warren, MI 48090

1. The basic correspondence is forwarded for your action.

2. Your office is tasked to perform the subject study. Request that your evaluation plan for this study to include your milestones be forwarded to this Headquarters not later than 31 December 1976. In your evaluation plan include an in-process review (IPR) for the March 1977 time frame. The final study will be forwarded to this Headquarters not later than 16 May 1977. Contact point for this Headquarters is Captain Hughes, Autovon 284-8574/75.

FOR THE COMMANDER:

2 Incl
nc

R. D. DESCOTEAU
Colonel, GS
Associate Director
for Maintenance

Swartz

DEPARTMENT OF THE ARMY
US ARMY TANK-AUTOMOTIVE MATERIEL READINESS COMMAND
WARREN, MICHIGAN 48090 Mr. Swartz/lvm
AUTOVON 369-2610

DRSTA-MSA 16 FEB 1977

SUBJECT: Life Expectancy Years and Miles for Commercial Design Vehicles

Commander
US Army Materiel Development
and Readiness Command
ATTN: DRCMM-MS
5001 Eisenhower Avenue
Alexandria, VA 22333

1. Reference 1st Ind, DRCMM-MS, dated 9 December 1976, subject as above.

2. The following subject study plan is provided to meet the objective of maximum economical life expectancy by assuring operation at the lowest average cost/mile. Consideration will be given to age, mileage and cost of vehicle repair.

a. Coordination with other government agencies to eliminate any duplication of effort.

b. Life expectancy assessment methodology selection:

(1) Method 1: A cursory method which would involve very minimal solid data backing or analysis, and employing a high degree of estimation and projection.

(2) Method 2: Extensive assessment utilizing present methodology employed by USAMSAA, which required substantial statistical data collection and analysis as follows:

(a) Examine available data bases.

(b) If available data cover all requirements, prepare data to conform to study format requirements.

(c) If data available do not cover all requirements, develop and implement a data collection program.

(d) Develop computer programs.

(e) Initiate data processing.

(f) Conduct life cycle cost analyses by system.

(g) Conduct vehicle performance analysis by system.

(h) Compare results with other data sources.

(i) Prepare draft report.

(j) Prepare final report.

3. Two possible study methods could be employed. Method 1 could be implemented by May 1977, but would have very little solid data backing and is not recommended. Method 2 is the method currently utilized by USAMSAA which, from past experience, has taken 1.5 years per vehicle system. An accurate estimate of study length will depend on the availability of data and cannot be provided until an examination of available data is made. From initial contacts with GSA, it was learned that extensive statistical data collection efforts were and are being employed to establish their economical vehicle replacement criteria. Their efforts tend to support our recommendation to utilize the USAMSAA methodology.

4. Prior to implementation of either study methodology, it is imperative that study priorities be placed on this and other study requirements established by your headquarters. Due to critical manpower limitations, further consideration on implementation of this study effort would require the postponement or re-scheduling of the Combat Vehicle

DRSTA-MSA 16 FEB 1977

SUBJECT: Life Expectancy Years and Miles for Commercial Design Vehicles

Maintenance Policy (CVMP) Study and Reliability Centered Maintenance Strategy (RCMS) Implementation Study.

FOR THE COMMANDER:

RICHARD L. BRYANT
Colonel, GS
Director of Maintenance (NMP)

CF:
Cdr, USAMSAA
ATTN: DRXSY-RE,
Mr. R. Bell
APG, MD 21005

3

DRCMM-MS (16 Feb 77) 1st Ind
SUBJECT: **Life Expectancy Years and Miles for Commercial Design Vehicles**

Headquarters, US Army Materiel Development and Readiness Command,
5001 Eisenhower Avenue, Alexandria, VA 22333 15 APR 1977

TO: Commander, US Army Tank Automotive Materiel Readiness Command,
ATTN: DRSTA-MS, Warren, MI 48090

1. The proposed study plan has been examined in detail and discussions conducted with the DA action officer, Mr. Bird. Based on these considerations, Method 2 as outlined in the basic correspondence, is the approach which will best provide the required information.

2. The postponement of the Combat Vehicle Maintenance Policy Study and Reliability Centered Maintenance Strategy (RCMS) Implementation Study is not appropriate. Request your recommendation as to other lower priority programs that can be deferred or stretched out.

3. Request that your office take action to initiate this study using Method 2. A complete study plan to include milestone charts will be provided this office NLT 16 May 1977.

FOR THE COMMANDER:

R. D. DESCOTEAU
Colonel, GS
Associate Director for Maintenance

DEPARTMENT OF THE ARMY
US ARMY TANK-AUTOMOTIVE MATERIEL READINESS COMMAND
WARREN, MICHIGAN 48090

DRSTA-MSA

17 MAY 1977

SUBJECT: Life Expectancy Years and Miles for Commercial Design Vehicles

Director
US Army Materiel Systems
Analysis Activity
ATTN: DRXSY-R
Aberdeen Proving Ground, MD 21005

1. Reference is made to:

a. 1st Ind, DRCMM-MS, dated 9 December 1976, subject as above (Incl 1).

b. 2d Ind, DRSTA-MSA, dated 17 January 1977, subject as above (Incl 2).

c. Letter, DRSTA-MSA, dated 16 February 1977, subject as above (Incl 3).

d. 1st Ind, DRCMM-MS, dated 15 April 1977, subject as above (Incl 4).

2. The scope of effort required to implement the DARCOM task stated in reference 1a exceeds our current manpower capacity. Coordination has been initiated with Mr. Ray Bell, of your agency, on the determination of the effort required to accomplish this task.

3. The two study efforts mentioned in reference 1c are fully utilizing our limited capability in this area. Request that a representative of your office contact Mr. Donald Swartz (AUTOVON 369-2610) to discuss the possibility of employing the assistance of your agency to accomplish this task.

FOR THE COMMANDER:

4 Incl
as

RICHARD L. BRYANT
Colonel, GS
Director of Maintenance (NMP)

Mr. Bell/dkn/283-2135

DRXSY-RE 12 SEP 1977

SUBJECT: Commercial Design Vehicle Study

Commander
US Army Tank-Automotive Materiel
Readiness Command
ATTN: DRSTA-MSA
Warren, MI 48090

1. Reference is made to:

a. DRSTA-MSA letter, dated 17 May 1977, subject: Life Expectancy Years and Miles for Commercial Design Vehicles.

b. DRSTA-MSA letter, dated 30 June 1977, subject: Update of DODI 4151.10 "Maintenance Man-hour Input Standards for Commercial (Transport) Design Motor Vehicles."

c. DRSTA-MSA TWX, dated 2 June 1977, subject: Life Expectancy Years and Miles for Commercial Design Vehicles.

d. IPR on Commercial Design Vehicle Study held at DARCOM on 10 August 1977.

e. DRSTA-MSA letter, dated 2 September 1977, subject as above.

2. As indicated in reference 1.c., the formal acceptance of the subject study by AMSAA was to be provided to TARCOM upon completion of the data availability assessment. This assessment has essentially been completed with the general finding that the currently existing Administrative Vehicle Management System (AVMS) data base will be suitable for conducting the study. As a result, AMSAA will conduct the study as requested. The study will have two basic objectives: (1) reassess the life expectancies (years/miles) of commercial design vehicles (as contained in DODI 4150.4) and (2) re-evaluate the maintenance man-hour input standards for commercial design vehicles (as contained in DODI 4151.10). It is noted that the study was considered to

have been initiated in August 1977 and is expected to be completed in June 1979 (a detailed milestone schedule is provided as Inclosure 1). AMSAA will require funds in the amount of $100,000 during FY78 for the conduct of study with possibly some additional funds required for FY79. The $100K for FY78 will be for 1.5 man-years of effort plus $40K for computer usage.

3. In carrying out the study, AVMS data will be utilized in obtaining maintenance costs for the vehicles under study. AVMS data will be collected at six different sites (Fts. Benning, Lewis, Shafter and Knox; APG and WSMR) beginning 1 October 1977 for approximately one year. These sites were selected because they contain the largest quantities and have the widest diversification of types of administrative vehicles. It is anticipated that data will be collected on a total of approximately 6000 vehicles at these six sites.

4. As indicated in the IPR of reference 1.d., the determination of the life expectancy of the commercial design administrative vehicles will be arrived at through an evaluation of the economic life of these vehicles (the mileage/years in which the overall cost to procure and maintain these vehicles is at a minimum to the Army) supplemented by a RAM analysis of these vehicles over the economic life span to determine if the life expectancy should be less than the economic life because of RAM considerations. During the course of these evaluations maintenance man-hour requirements will be developed for comparison with the standards contained in DODI 4151.10. At the referenced IPR, the DA representative requested that if possible, each of the 92 Line Item Number Vehicles be evaluated separately. During the conduct of the study each vehicle in which sufficient sample size is available for the determination of a maintenance cost model will be evaluated separately. Those vehicles with small sample sizes will be appropriately combined with other vehicles for evaluation purposes.

5. In connection with including Maintenance & Service (M&S) Vehicles, (reference 1.e.) in the study, inclusion of these type vehicles in study appears feasible. Initial discussions with at least one data collection site (APG) indicates that maintenance data on these type vehicles is also being collected under the AVMS.

12 SEP 1977

DRXSY-RE
SUBJECT: Commercial Design Vehicle Study

6. In summary, AMSAA will conduct the requested Commercial Design Vehicle Study. The study will include a life expectancy and maintenance man-hour analysis of commercial design administrative and M&S vehicles and will be conducted in accordance with the attached milestone schedule. Funds in the amount of $100,000 will be required for FY78. The point of contact at AMSAA is Mr. Raymond Bell, Autovon 283-2135.

FOR THE DIRECTOR:

Signed

1 Incl
as

RONALD L. SIMMONS
Acting Chief
RAM Division

CF:
Cdr, DARCOM, ATTN: DRCMM-MS (Capt. J. Hughes)
ATTN: DRCPA
Cdr, TARCOM, ATTN: DRSTA-FHC (Mr. E. Maltman)
Marion Smith, Budget Office

MILESTONE SCHEDULE

Aug 77	Initial IPR Review of study plan.
Aug/Sep 77	Discuss content of installation monthly maintenance report and feasibility of transferring data to AMMC with Ft. Knox, Ft. Benning, and APG.
Sep/Oct 77	Visit additional data collection sites (WSMR, Fts. Lewis and Shafter) to discuss implementation of data collection effort.
Sep 77	Discuss study with GSA/Navy/Air Force/FORSCOM/TRADOC.
Sep 77	Forward AMSAA's formal acceptance of study to TARCOM with study plan and funding requirements.
Oct 77	Initiate data collection effort.
Jan/Feb 78	Visit data collection sites to review data collection effort.
Apr 78	Review initial 6 months of data collection.
May/Jun 78	Revise existing computer programs on basis of initial data review.
Jun/Jul 78	Re-visit data collection sites to review data collection.
Sep/Oct 78	Complete data collection effort.
Nov 78	Receive data tapes from AMMC.
Nov 78	Initiate analysis of data.
Apr 79	Complete analysis of data.
May/Jun 79	Prepare interim report on study finding and provide briefings as required.

APPENDIX B

INDIVIDUAL VEHICLE TYPE REGRESSION FIT INFORMATION AND PLOTS

DATA SOURCE TRADOC 78

LIN BØ4441 NOMENCLATURE Auto Sedan Compact

Acquisition Cost $3500 Average Annual Mileage 13000

Fits based on all years

Instantaneous Maintenance Cost Years

$IMC(Y) = -6.6 + 150.13Y$

RSD = 471.64

Minimum Point ASC Y = 6.8

Value ASC at Minimum = $1019

Instantaneous Maintenance Cost Miles

$IMC(M) = .0138 + 6.13 \cdot 10^{-7} M$

RSD = 458

Minimum Point ASC Y = 10,860

Value ASC at Minimum = 8¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) = -13.72 + .0014\ (13000) + 9.54Y$

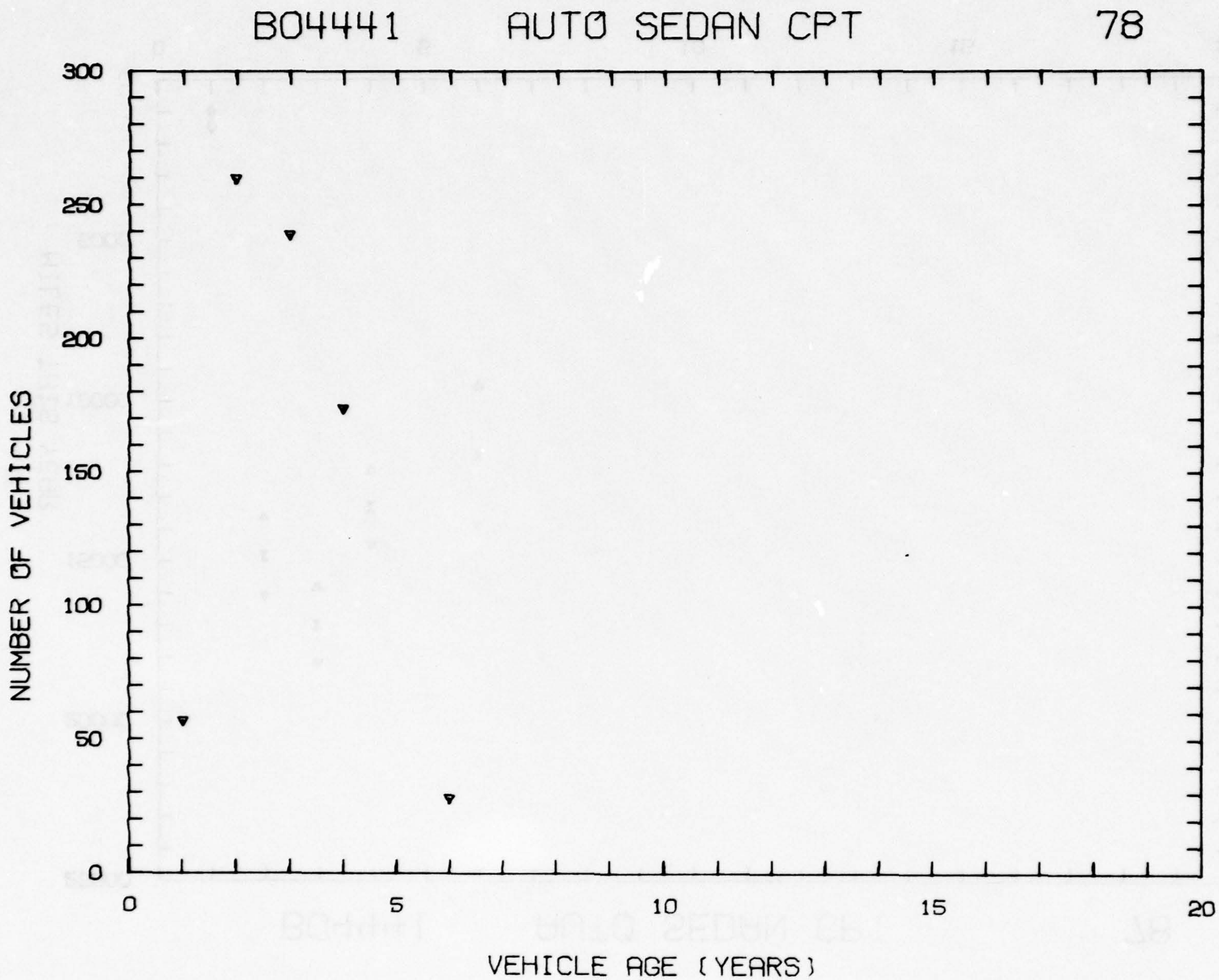
$= 4.48 + 9.54Y$

RSD = 30

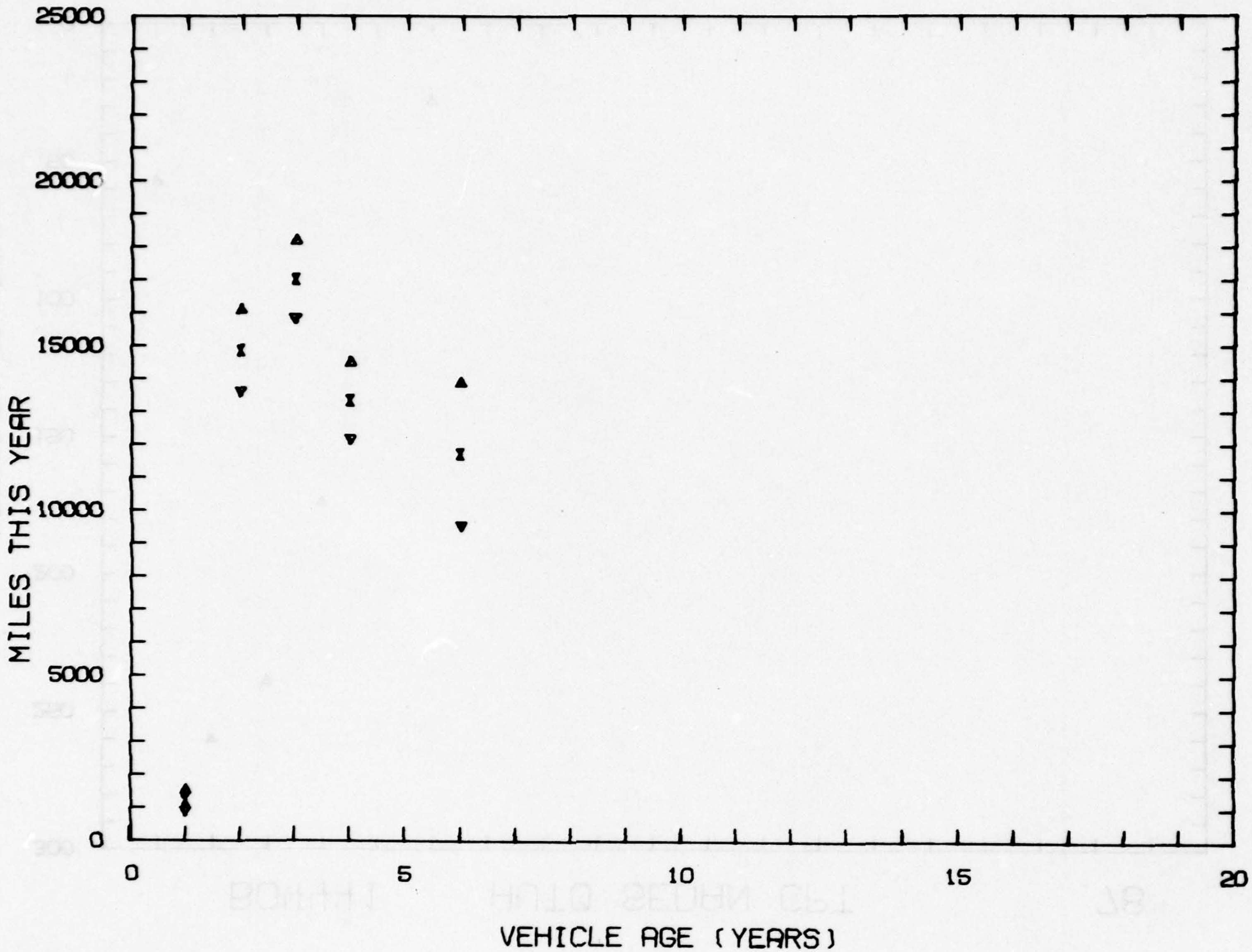
for each 1000 miles more than 13000 add 1.4 hours

less 13000 subtract 1.4

COMMENTS: Some 4 year old vehicles had very high costs, they all seemed to have the same manufacturer and perhaps should be replaced. Perhaps some falling of costs in the sixth year.


B04441 AUTO SEDAN CPT 78
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20

B04441 AUTO SEDAN CPT 78



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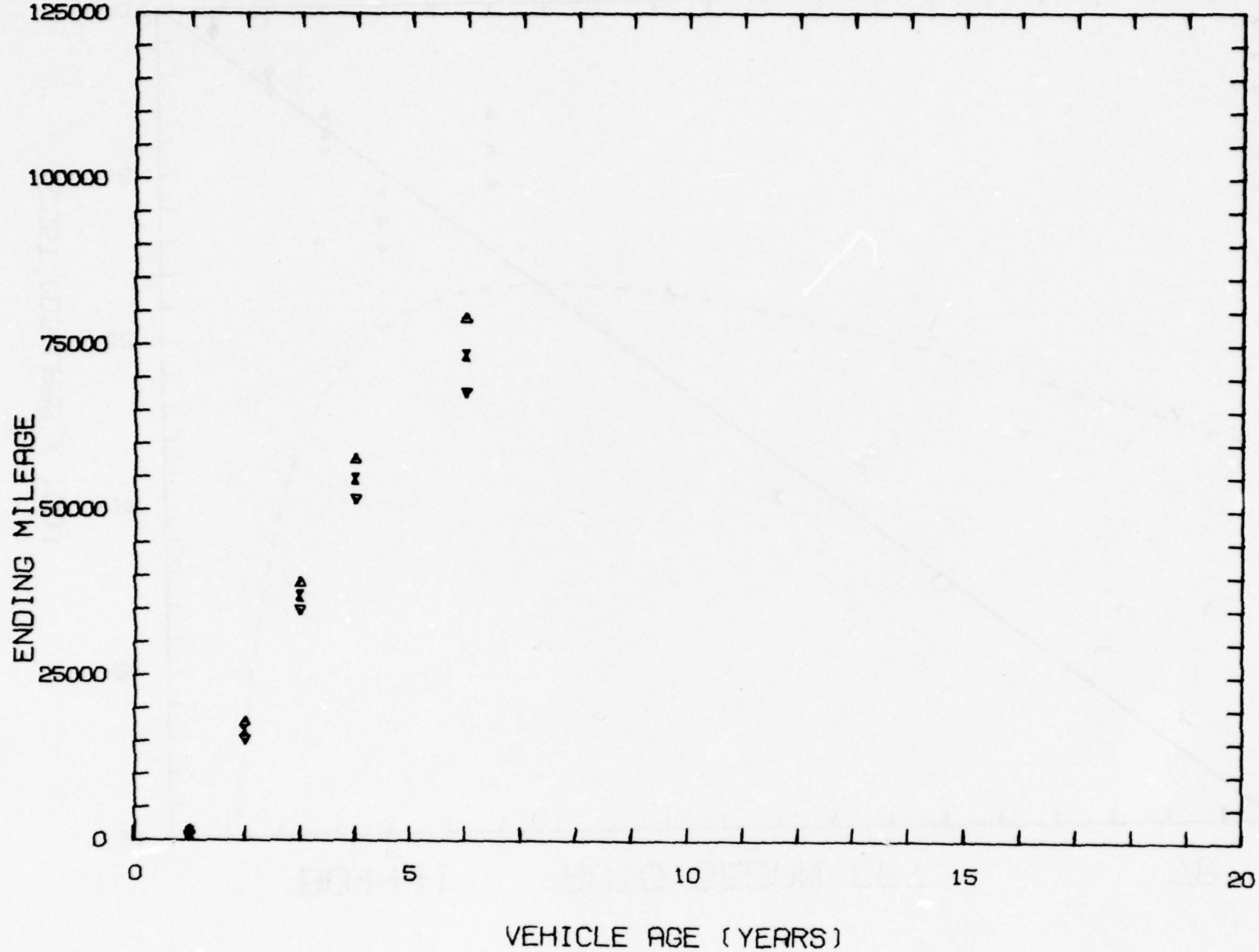
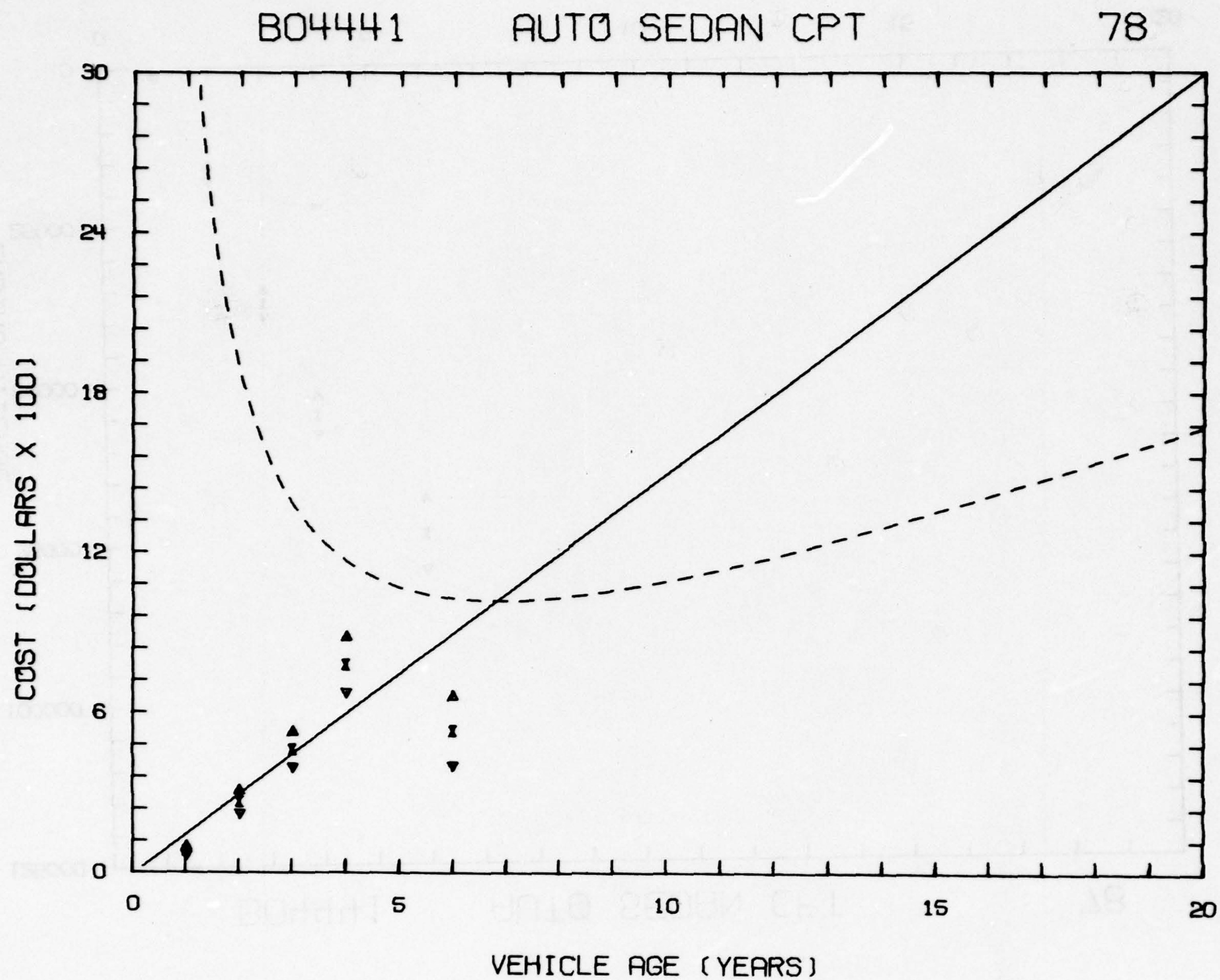
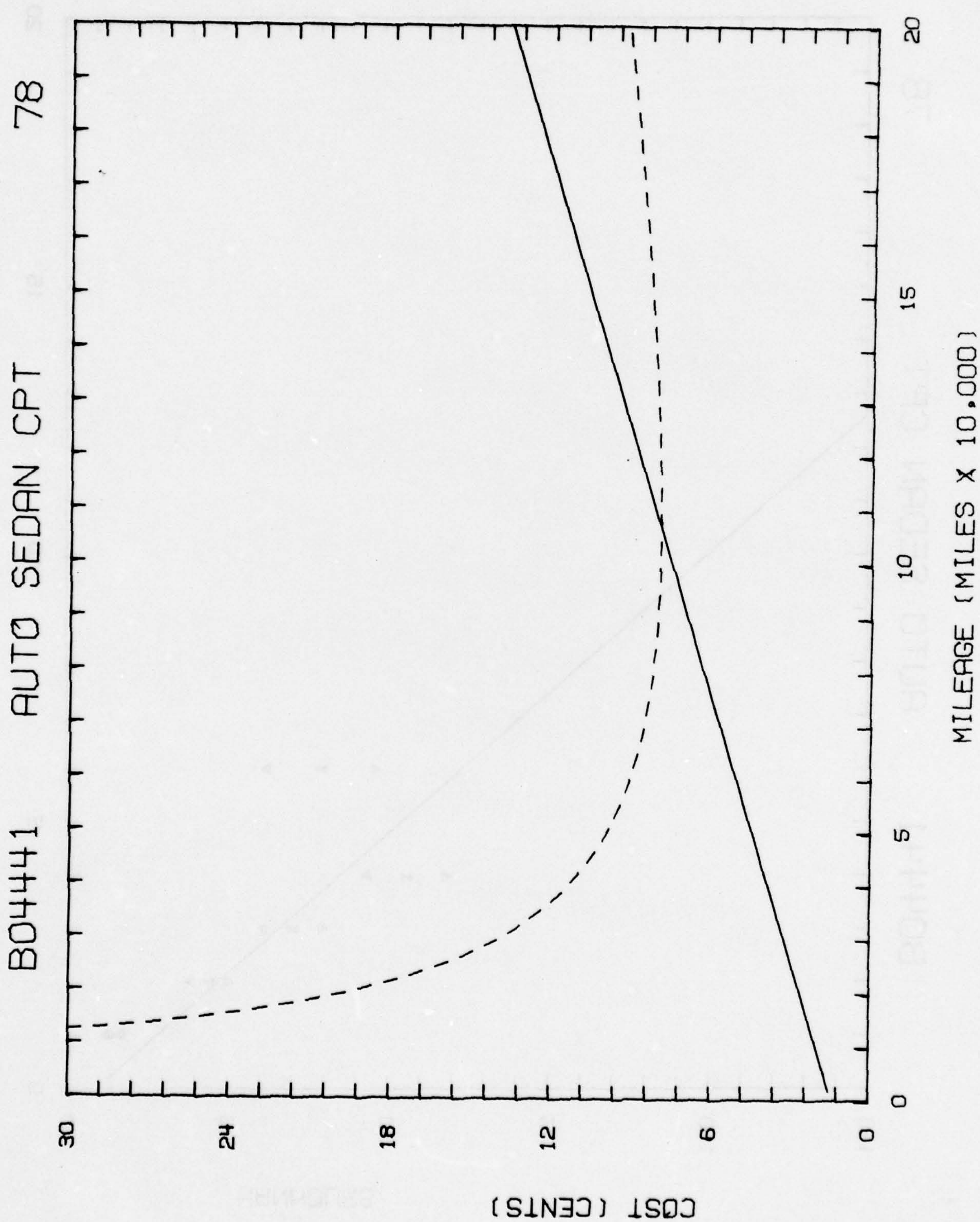
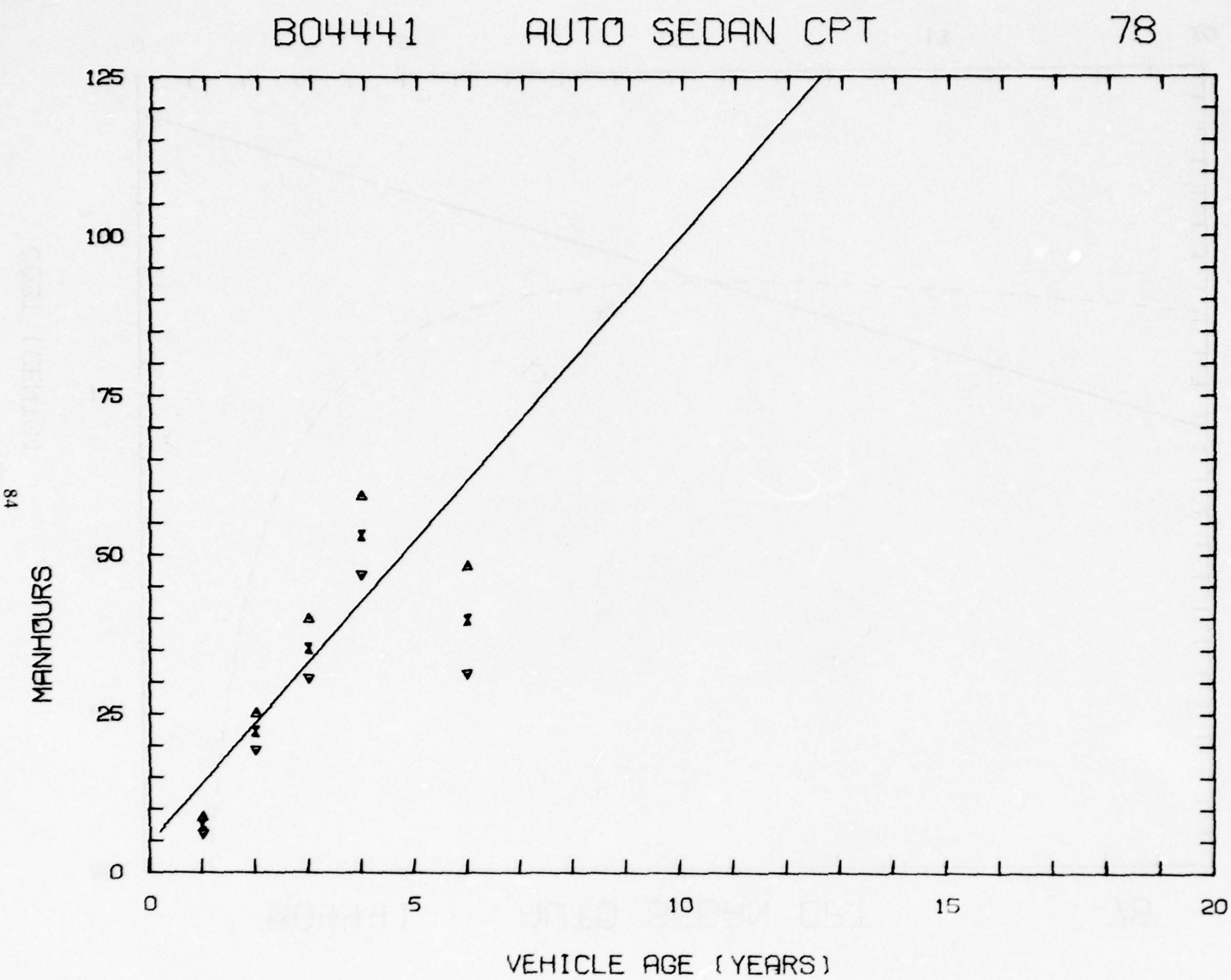
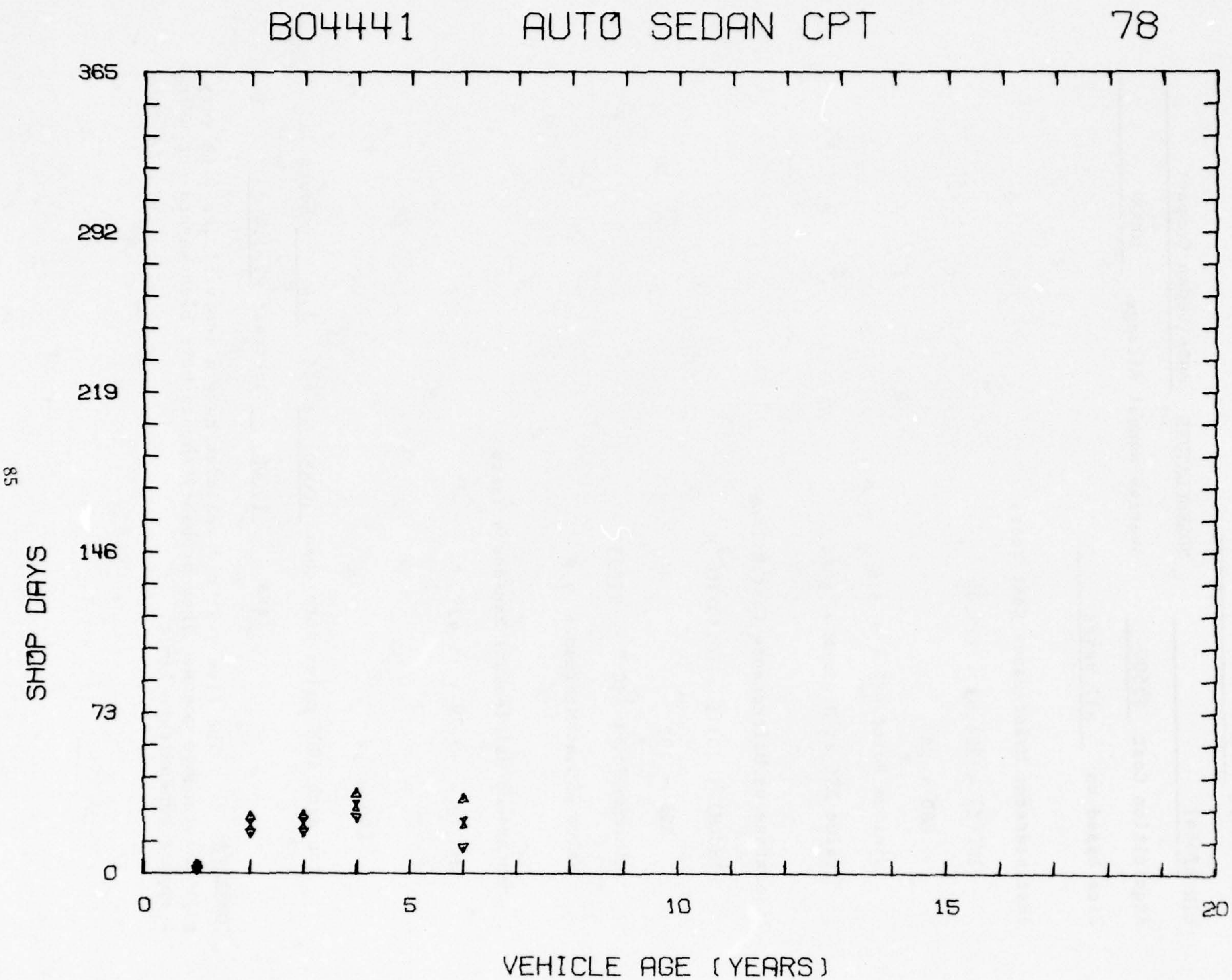




B04441
AUTO SEDAN CPT
78
COST (DOLLARS X 100)
30
24
18
12
6
0
0
5
10
15
20
VEHICLE AGE (YEARS)


B04441 AUTO SEDAN CPT 78
COST (CENTS)
30
24
18
12
6
0
0
5
10
15
20
MILEAGE (MILES X 10,000)


B04441
AUTO SEDAN CPT
78
125
100
75
50
25
0
MANHOURS
0
5
10
15
20
VEHICLE AGE (YEARS)


B04441 AUTO SEDAN CPT 78
SHOP DAYS
365
292
219
146
73
0
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN BØ4441 NOMENCLATURE Auto Sedan Compact

Acquisition Cost $3500 Average Annual Mileage 10000

Fits based on all years

Instantaneous Maintenance Cost Years

$IMC(Y) = 266.83 + 223.60$

RSD = 285

Minimum Point ASC Y = 5.6

Value ASC at Minimum = $984

Instantaneous Maintenance Cost Miles

$IMC(M) = .0112 + 10.53 \cdot 10^{-7} M$

RSD = 292

Minimum Point ASC Y = 81533

Value ASC at Minimum = 9.7

Instantaneous Maintenance Man-hours Years

$IMH(Y) = -9.79 + 11.42Y$

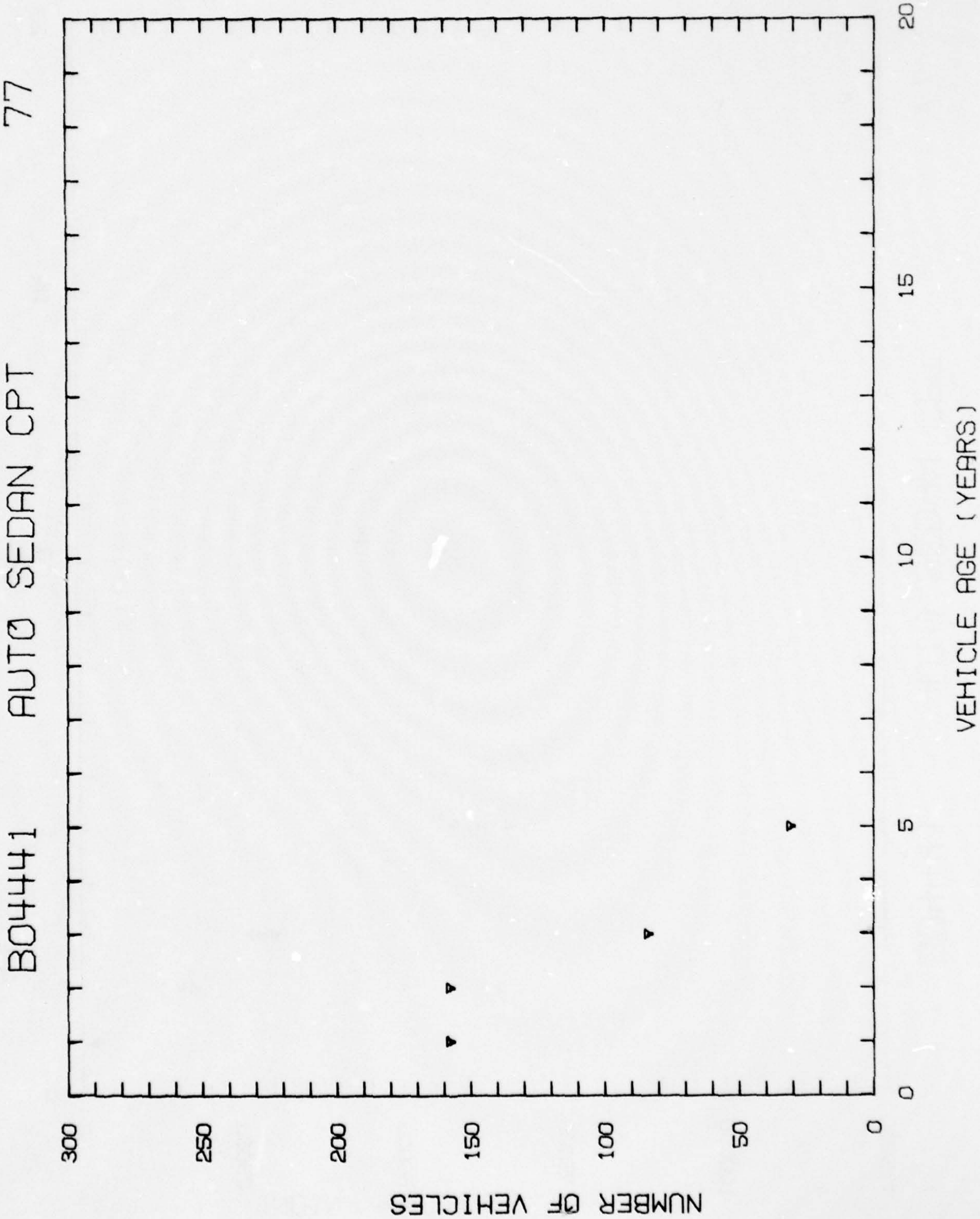
=

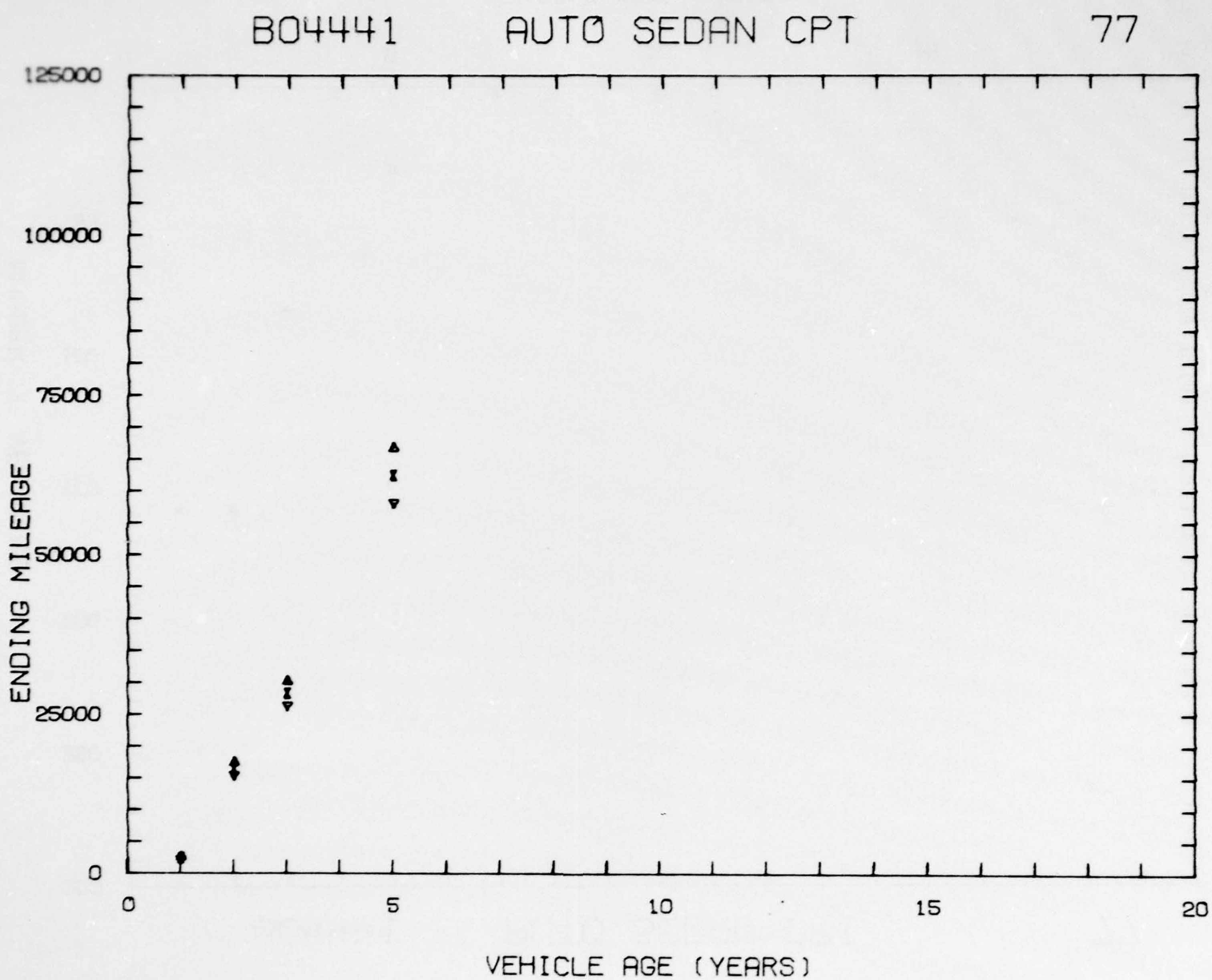
RSD = 13

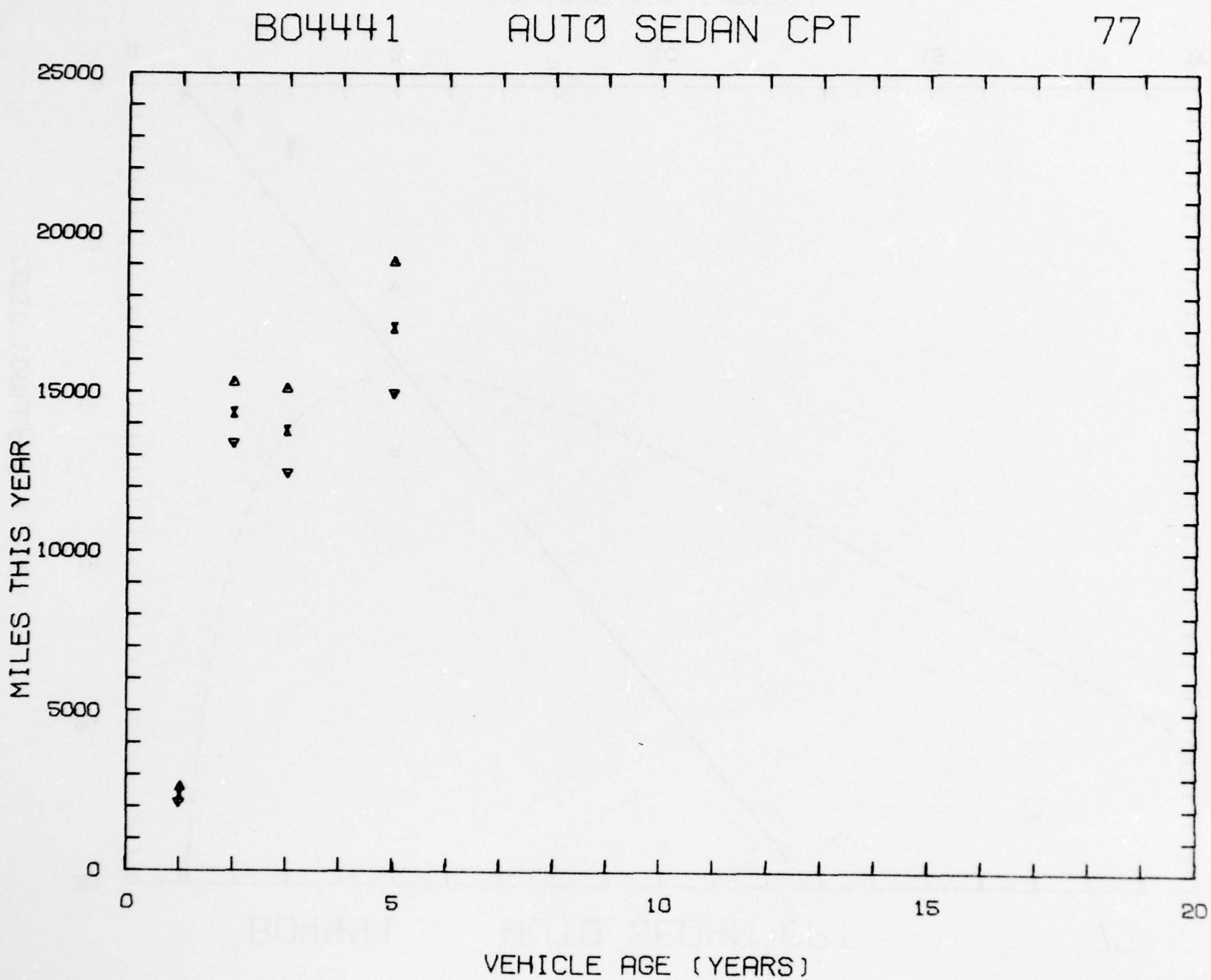
for each 1000 miles more than 10000 add 1.4 hours

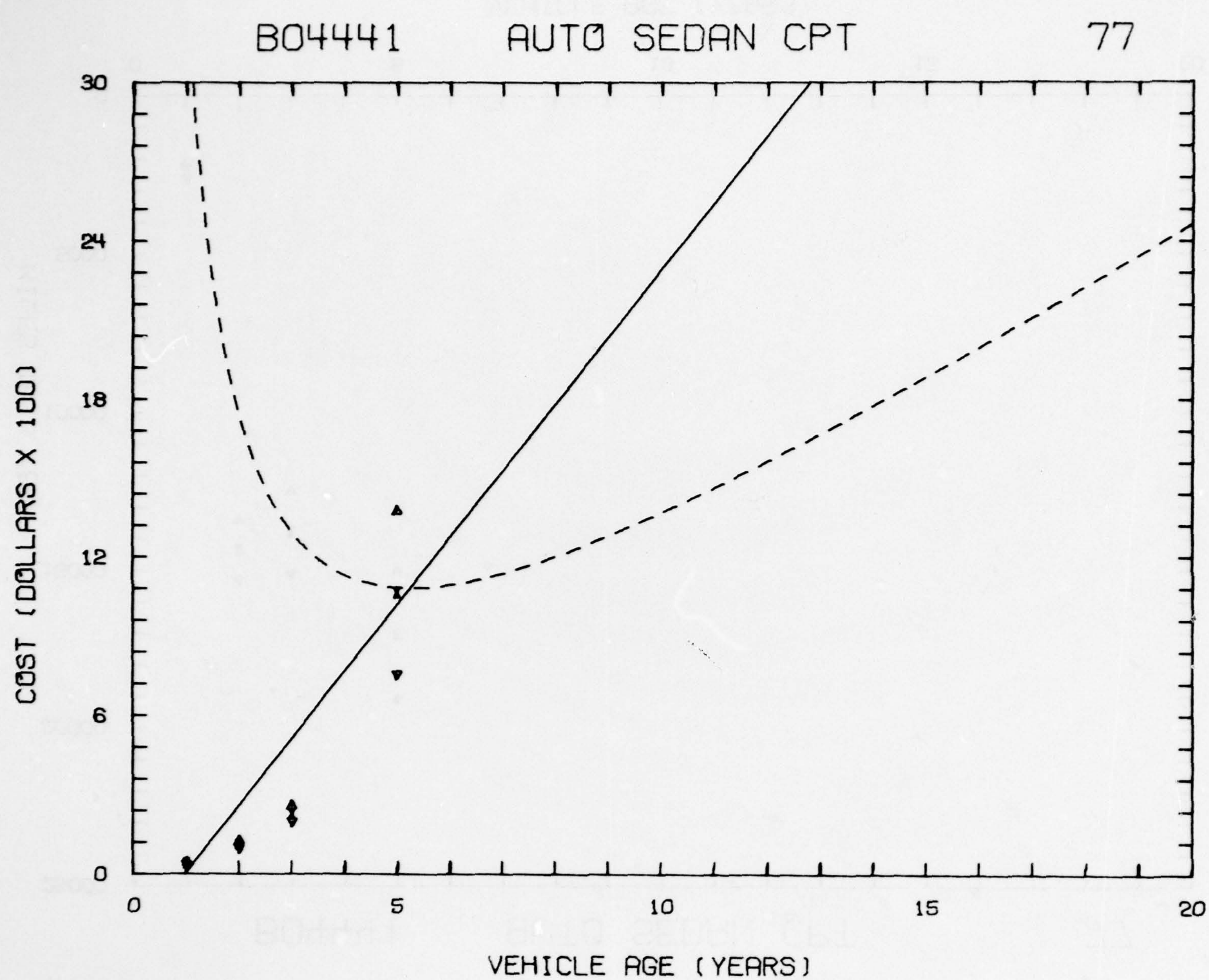
less 10000 subtract 1.4

COMMENTS: The five year old vehicles have a few vehicles with very high maintenance costs. They probably should have been washed out using a repair expenditure limit.

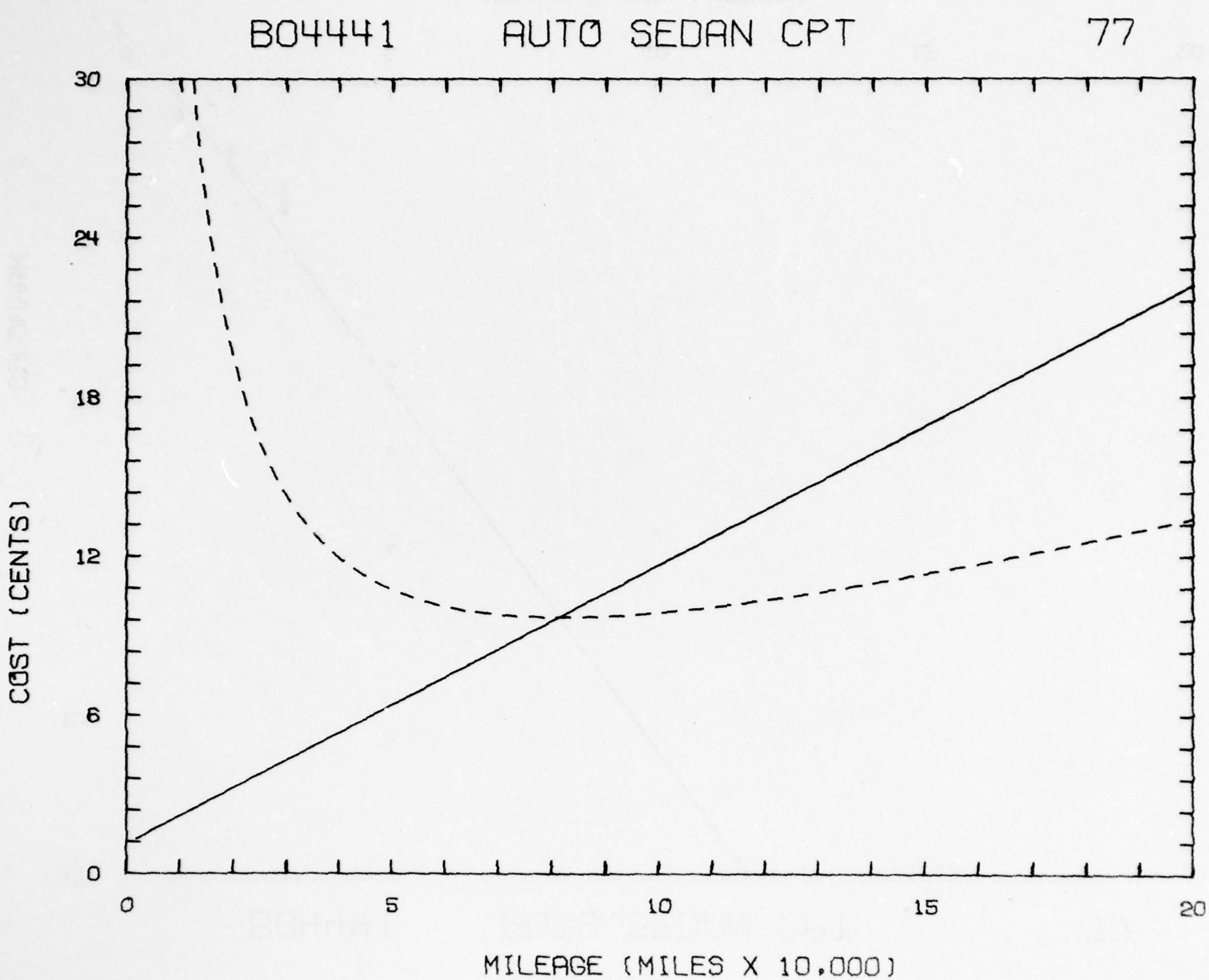

B04441 AUTO SEDAN CPT 77
NUMBER OF VEHICLES
300
250
200
150
100
50
0
0
5
10
15
20
VEHICLE AGE (YEARS)


B04441 AUTO SEDAN CPT 77
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)

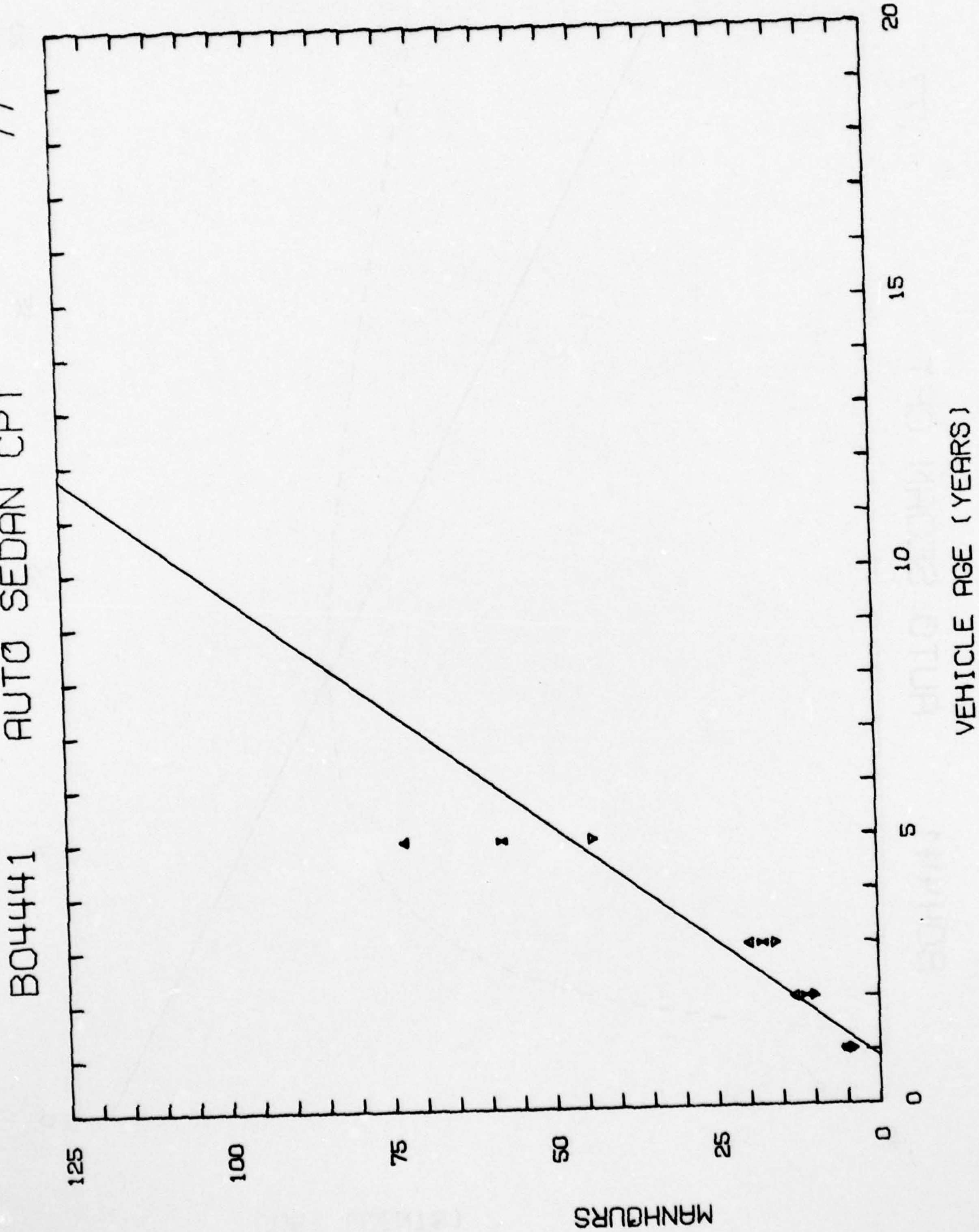

B04441 AUTØ SEDAN CPT 77
MILES THIS YEAR
25000
20000
15000
10000
5000
0
0
5
10
15
20
VEHICLE AGE (YEARS)



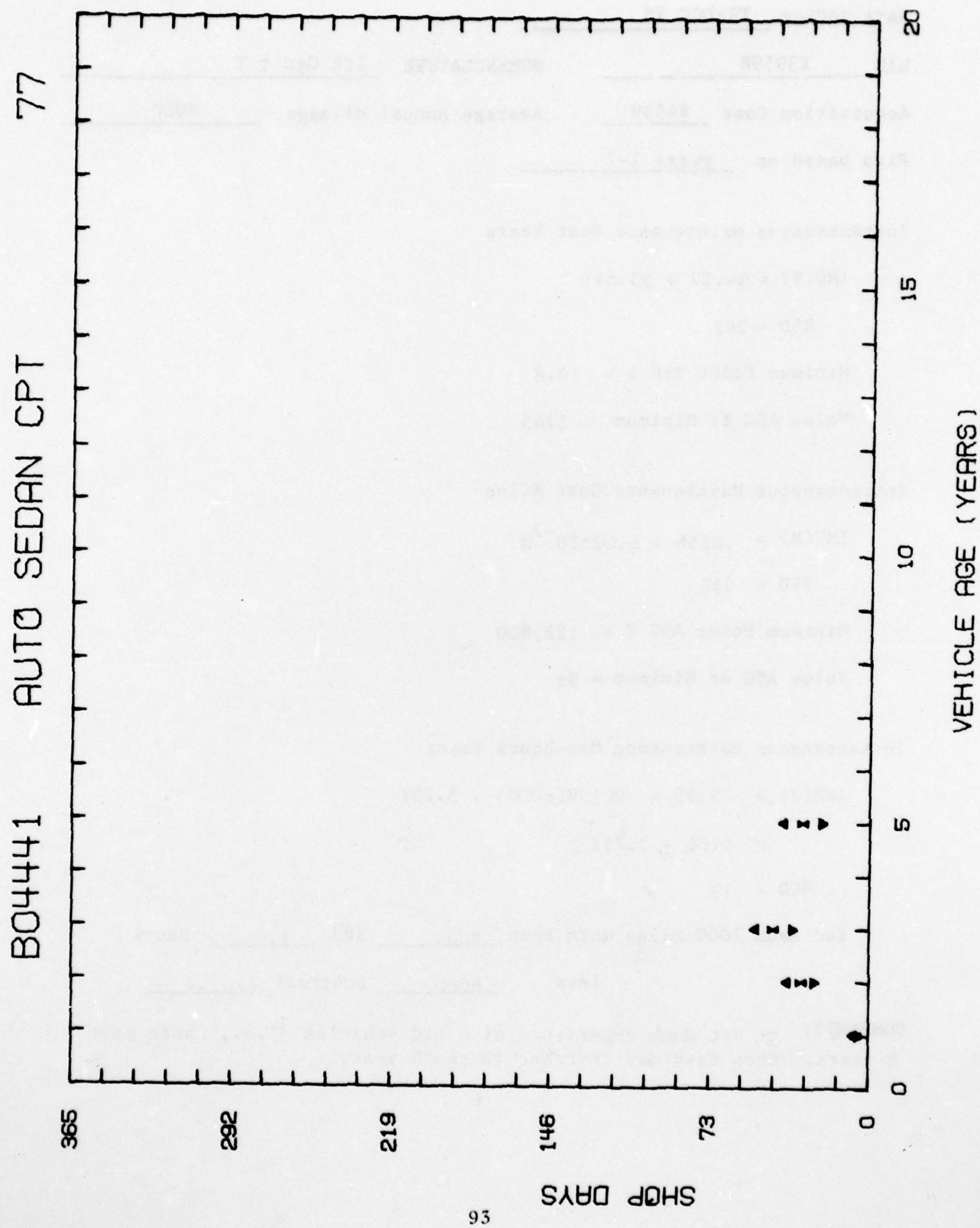
B04441 AUTO SEDAN CPT 77
30
24
18
12
6
0
COST (DOLLARS X 100)
0
5
10
15
20
VEHICLE AGE (YEARS)



B04441 AUTO SEDAN CPT 77
COST (CENTS)
30
24
18
12
6
0
0
5
10
15
20
MILEAGE (MILES X 10,000)



B04441 AUTO SEDAN CPT 77
MANHOURS
0
25
50
75
100
125
0
5
10
15
20
VEHICLE AGE (YEARS)


B04441 AUTO SEDAN CPT 77
SHOP DAYS
365
292
219
146
73
0
VEHICLE AGE (YEARS)
0
5
10
15
20

DATA SOURCE TRADOC 78

LIN X39598 NOMENCLATURE Trk Cgo ½ T

Acquisition Cost $4539 Average Annual Mileage 8000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 34.22 + 55.64Y$

RSD = 242

Minimum Point ASC Y = 12.8

Value ASC at Minimum = $745

Instantaneous Maintenance Cost Miles

$IMC(M) = .0156 + 6.02 \cdot 10^{-7} M$

RSD = 235

Minimum Point ASC Y = 122,800

Value ASC at Minimum = 9¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) = -5.38 + .00138(8000) + 3.75Y$

$= 5.66 + 3.75Y$

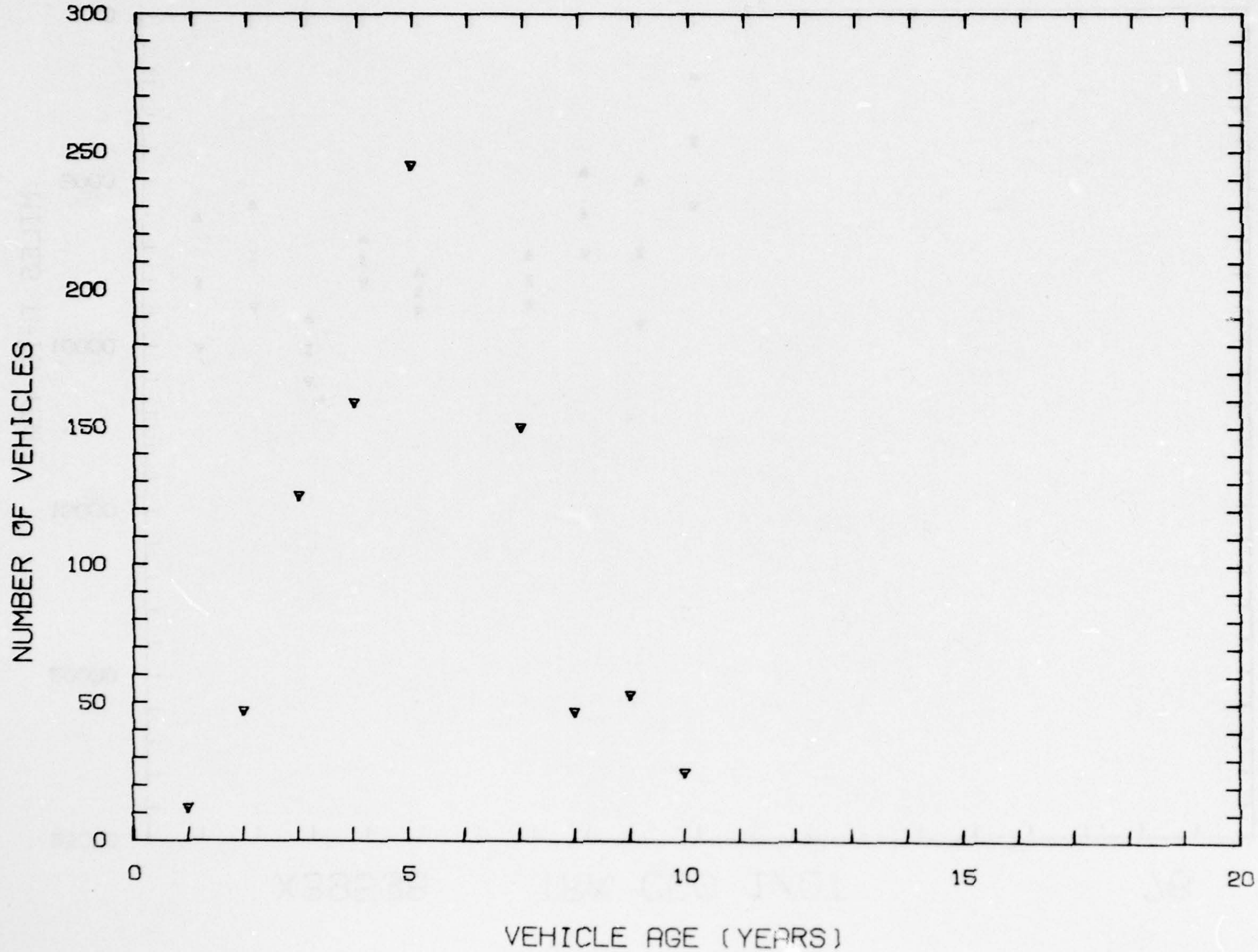
RSD = 17

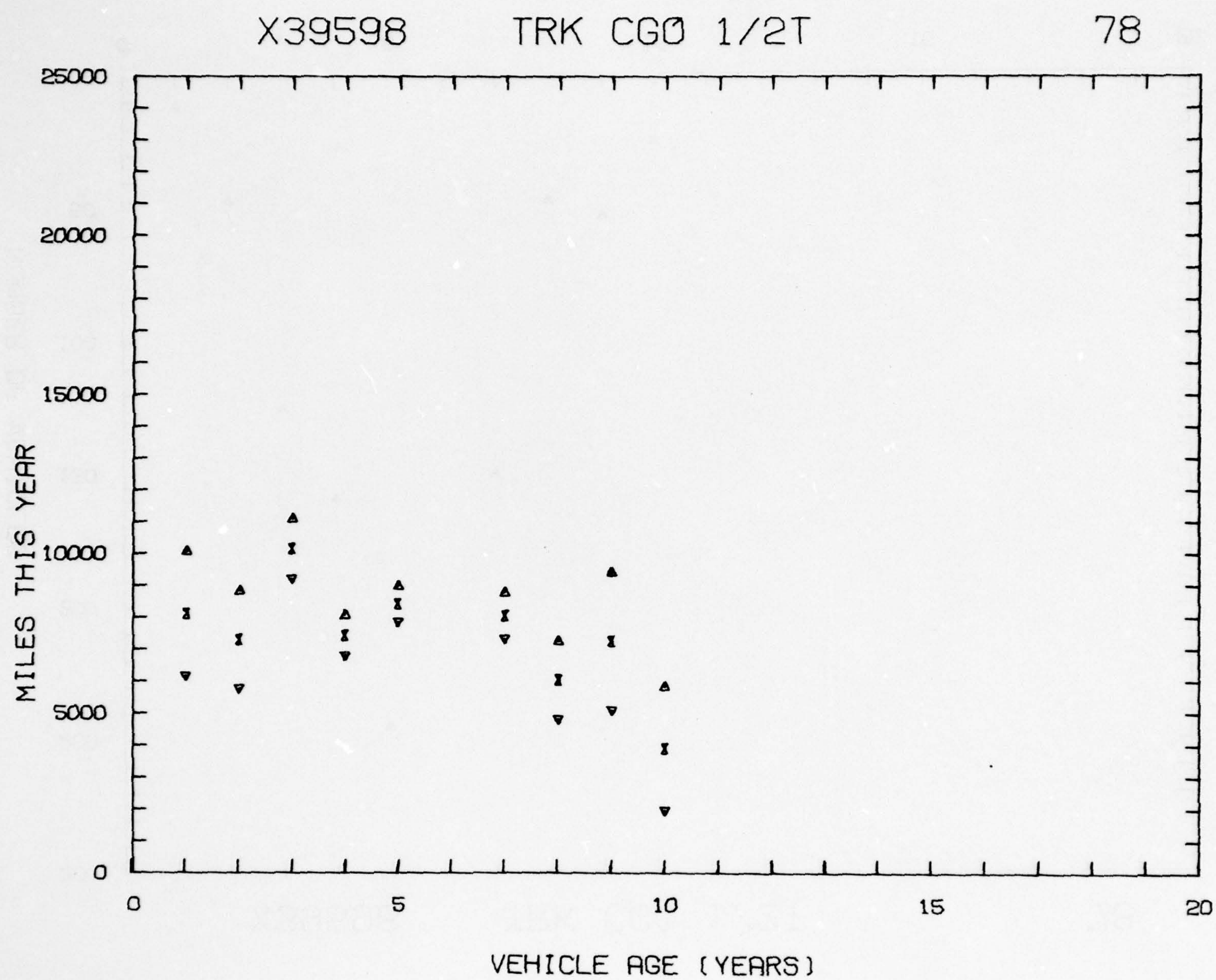
for each 1000 miles more than 8000 add 1.4 hours

less 8000 subtract 1.4

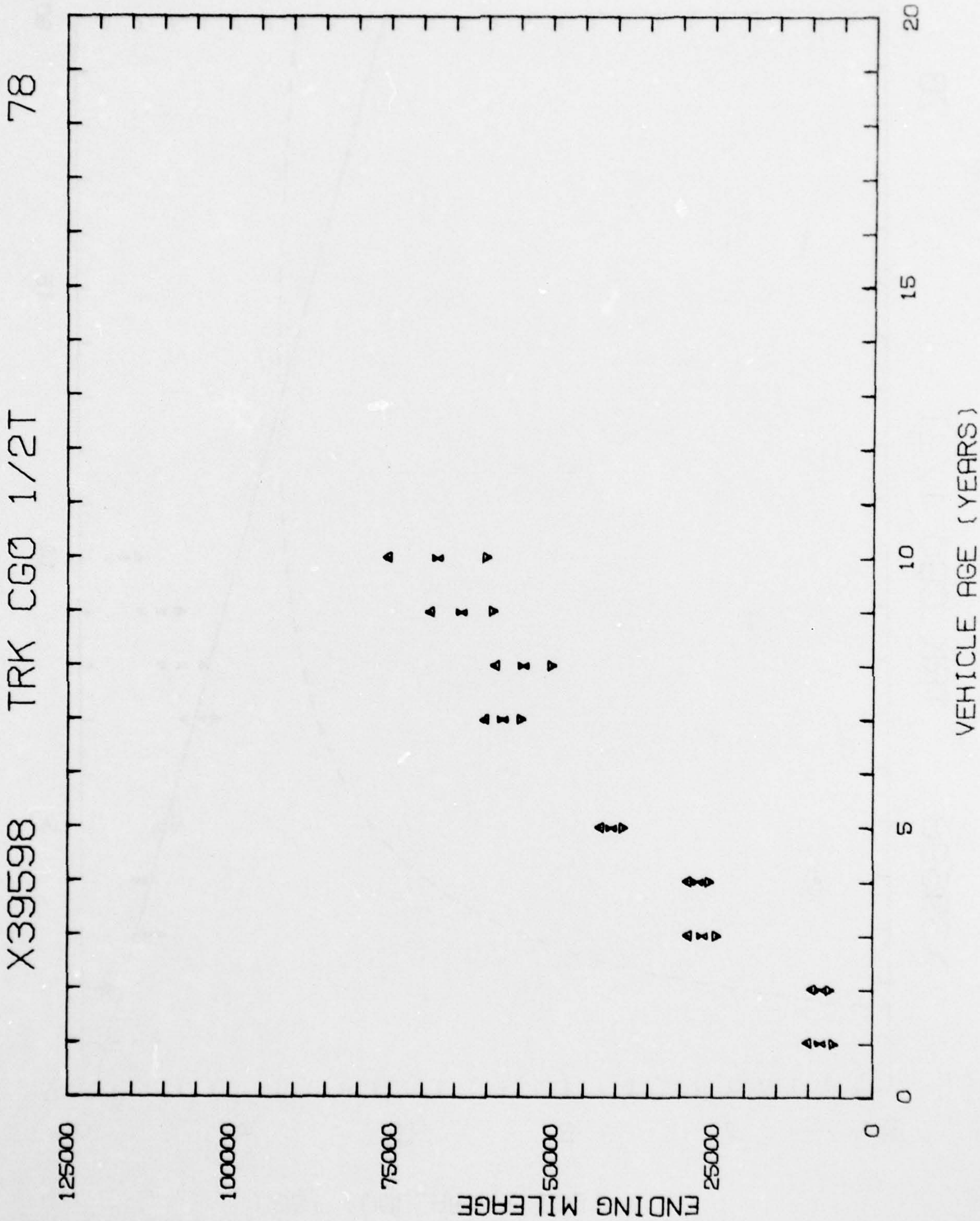
COMMENTS: Not much experience with old vehicles, i.e., those past 8 years. Shop days may increase in tenth year.

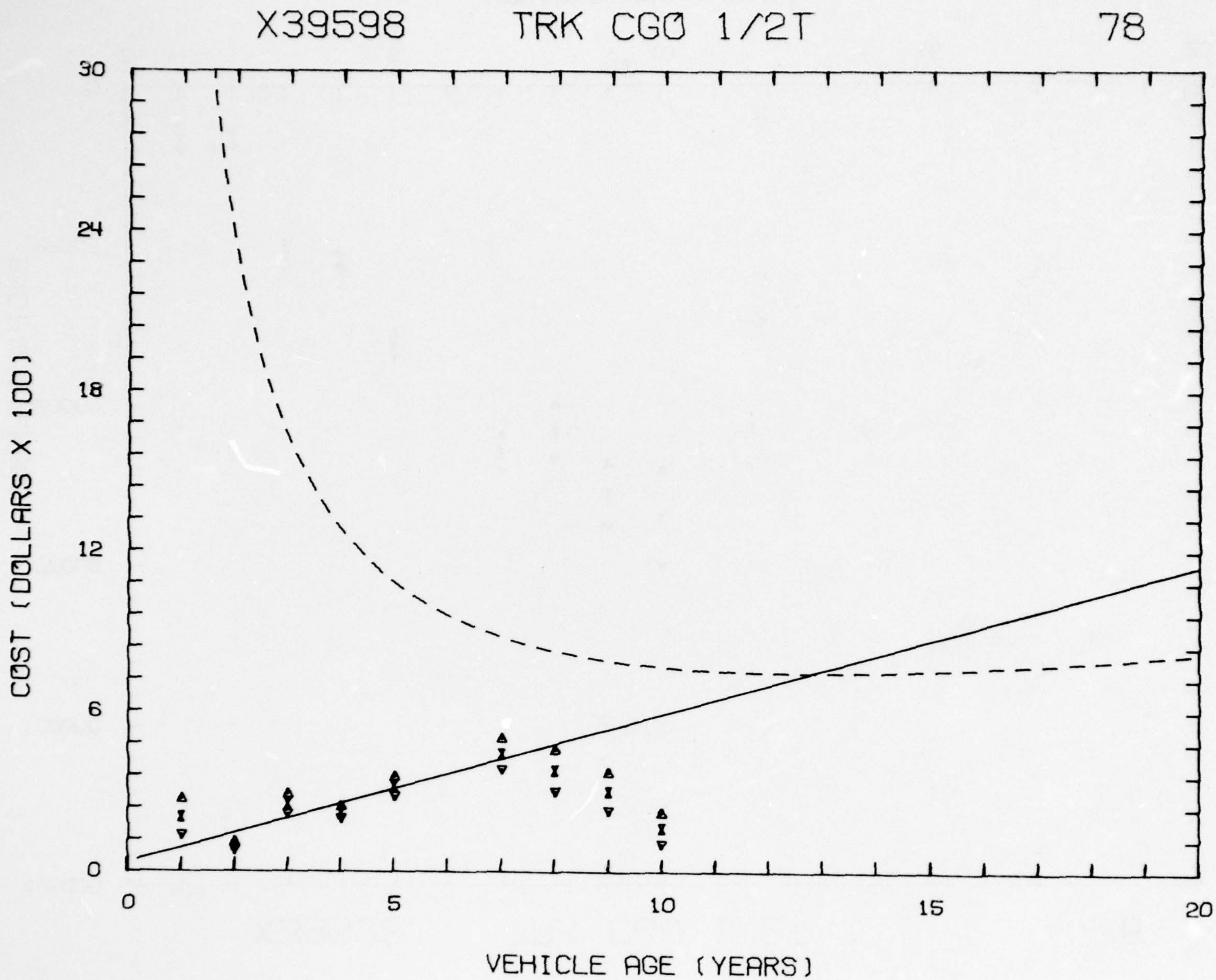
X39598 TRK CGØ 1/2T 78



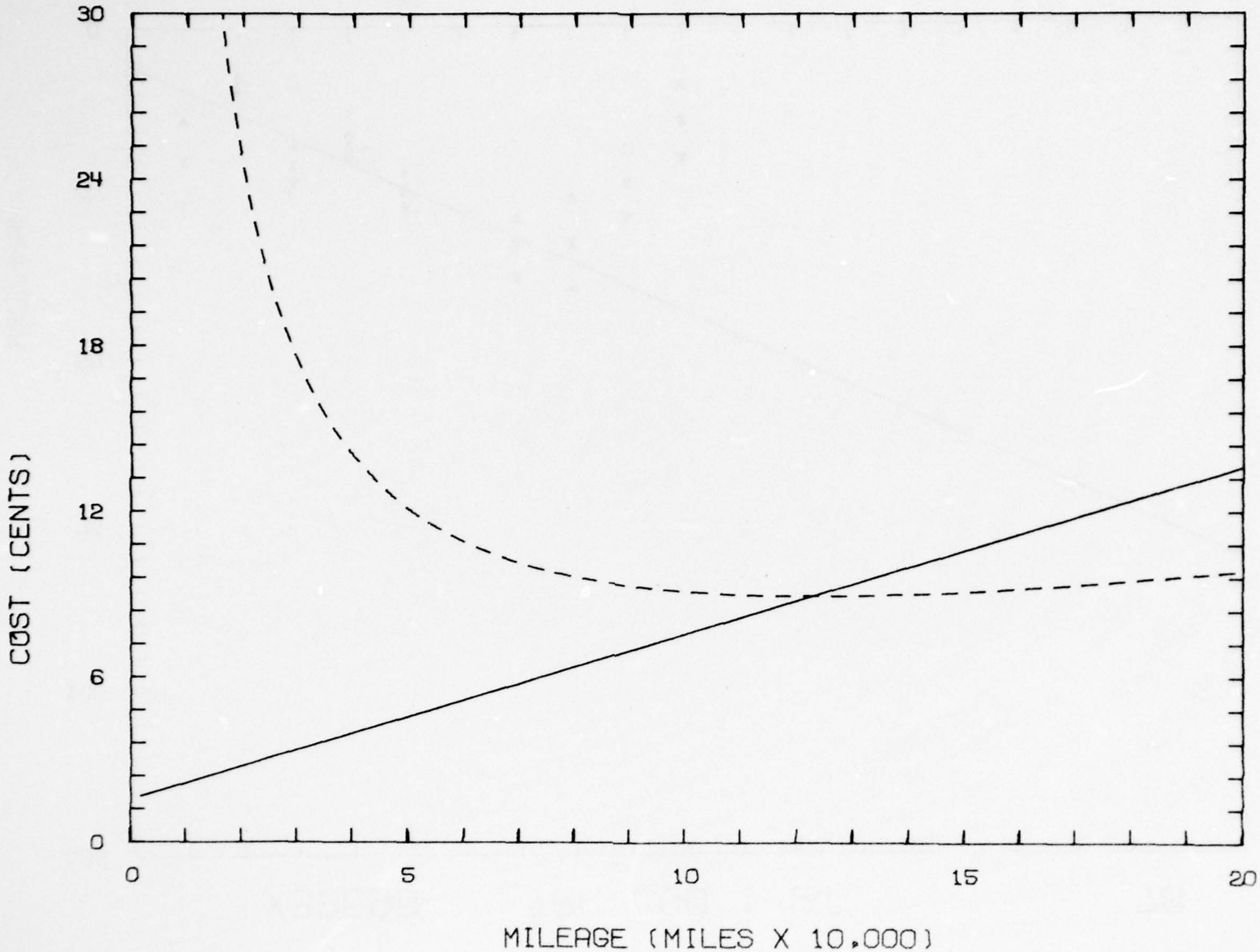


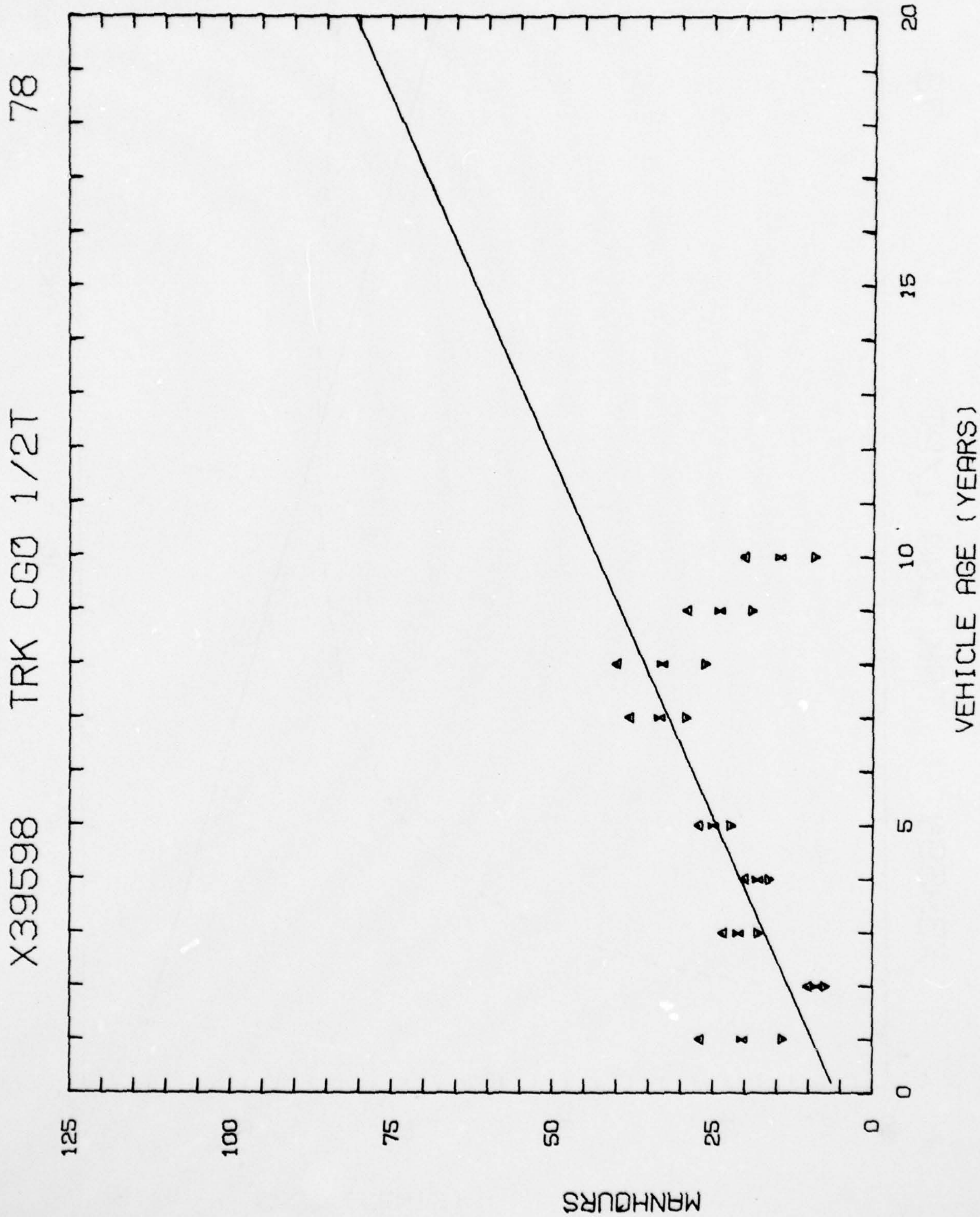
X39598 TRK CGØ 1/2T 78
MILES THIS YEAR
25000
20000
15000
10000
5000
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGØ 1/2T 78
ENDING MILEAGE
125000
100000
75000
50000
25000
0
VEHICLE AGE (YEARS)
0
5
10
15
20

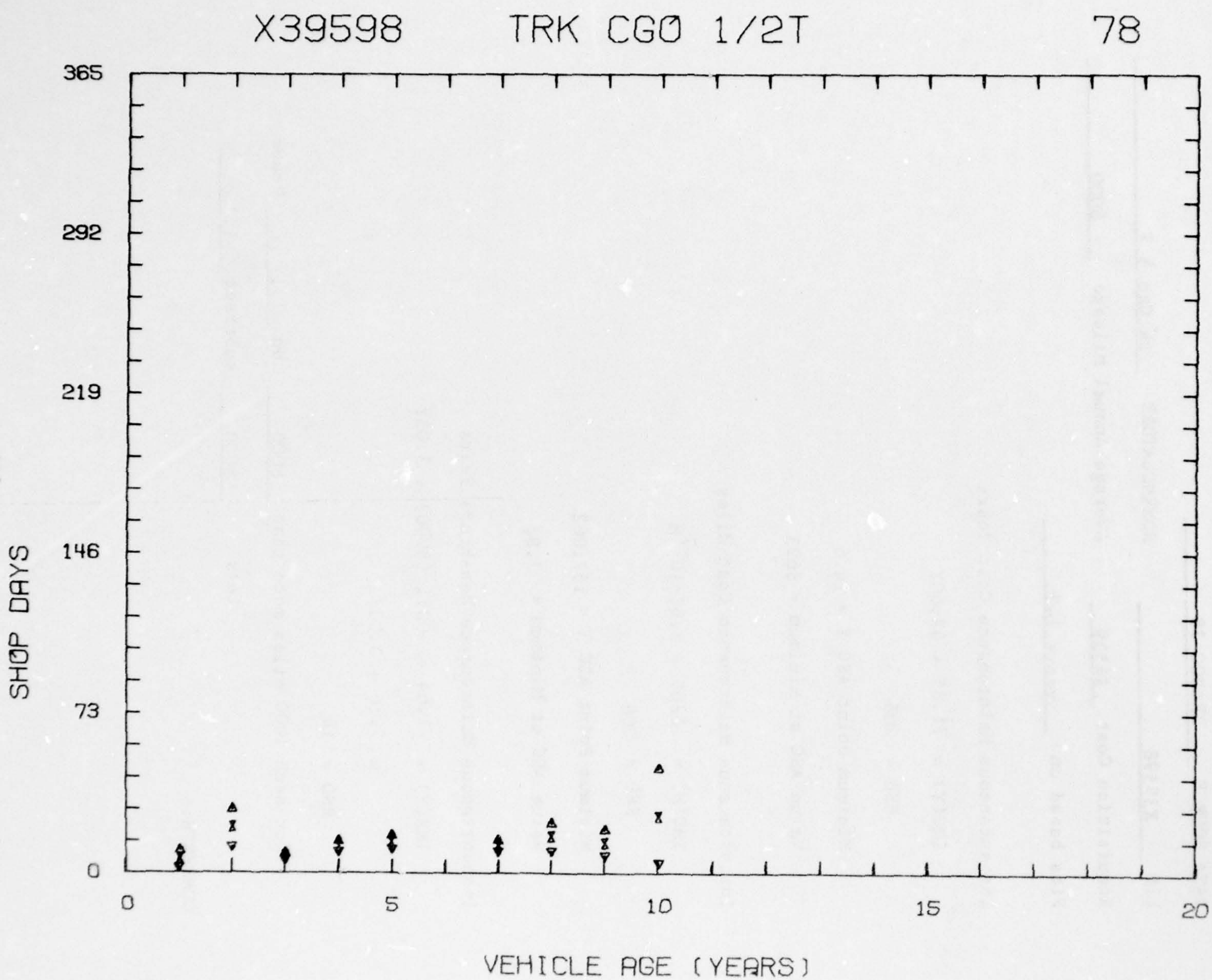

X39598 TRK CGØ 1/2T 78
COST (DOLLARS X 100)
30
24
18
12
6
0
5
10
15
20
VEHICLE AGE (YEARS)

X39598 TRK CGØ 1/2T 78





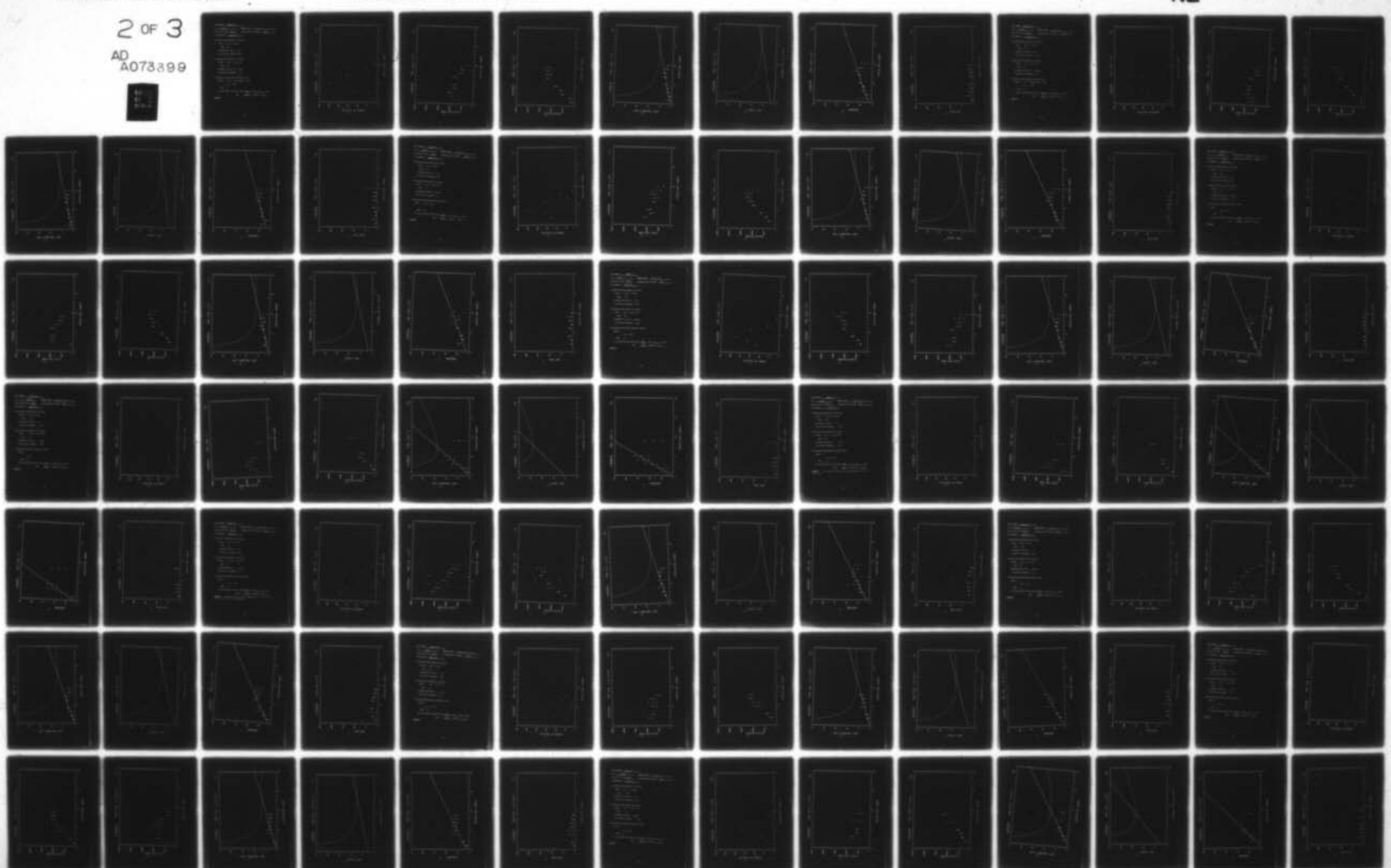
X39598 TRK CGO 1/2T 78
MANHOURS
125
100
75
50
25
0
0
5
10
15
20
VEHICLE AGE (YEARS)

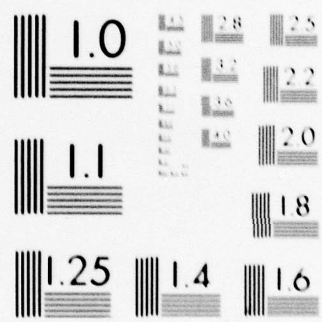


X39598
TRK CGØ 1/2T
78
365
292
219
146
73
0
SHØP DAYS
0
5
10
15
20
VEHICLE AGE (YEARS)

AD-A073 399 ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY ABERDEEN PROV--ETC F/G 13/6
ECONOMIC LIVES OF ADMINISTRATIVE USE VEHICLES.(U)
AUG 79 J J STREILEIN
UNCLASSIFIED AMSAA-TR-278 NL

2 OF 3
AD A073399





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

DATA SOURCE TRADOC 78

LIN X39598 NOMENCLATURE rk Cgo ½ T

Acquisition Cost $4539 Average Annual Mileage 8000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 71.85 + 42.60Y$

RSD = 208

Minimum Point ASC Y = 14.6

Value ASC at Minimum = $693

Instantaneous Maintenance Cost Miles

$IMC(M) = .0205 + 3.68 \cdot 10^{-7} M$

RSD = 206

Minimum Point ASC Y = 157,062

Value ASC at Minimum = 7.8¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) = -1.64 + .0011\ (8000) + 3.03Y$

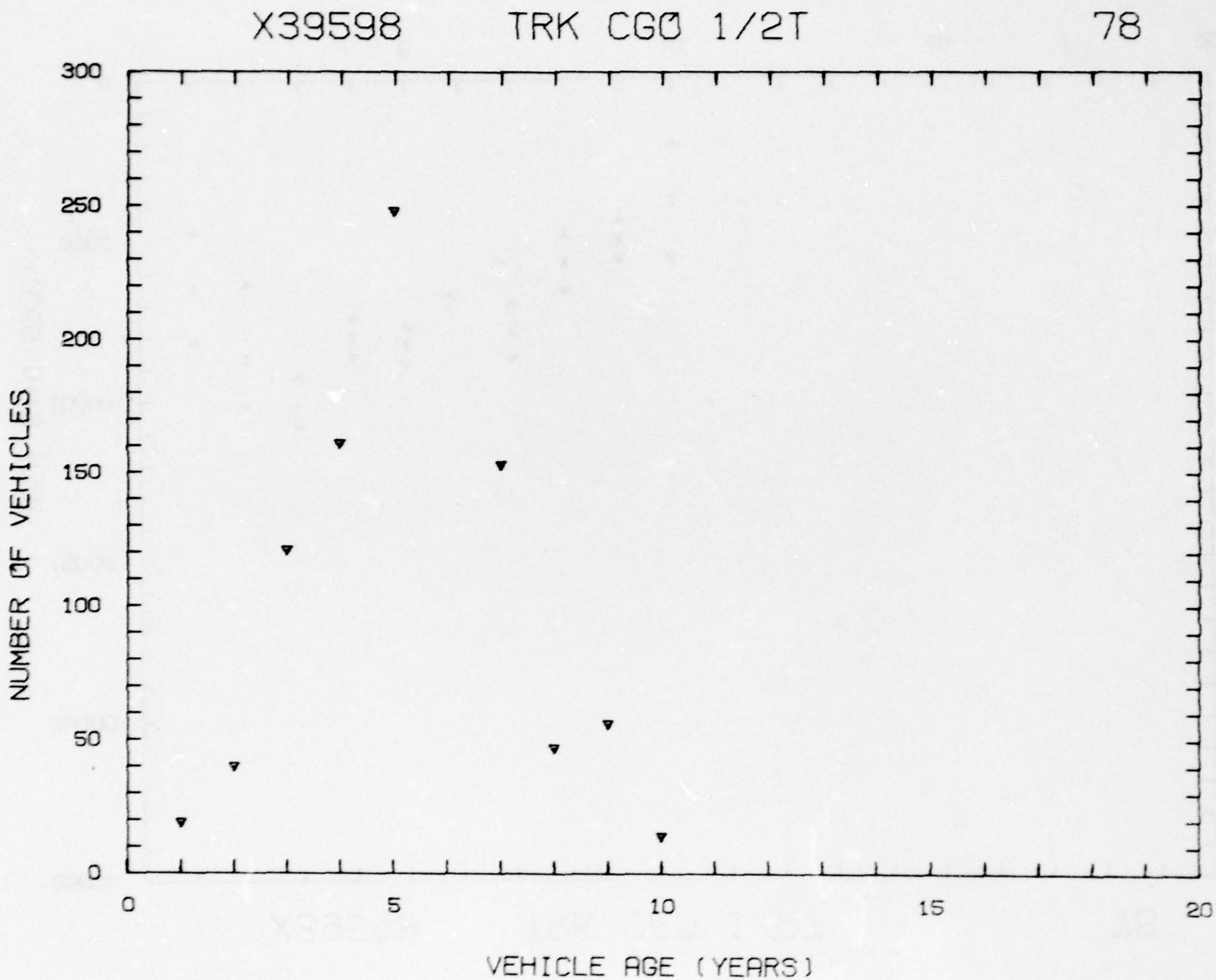
$= 7.16 + 3.03Y$

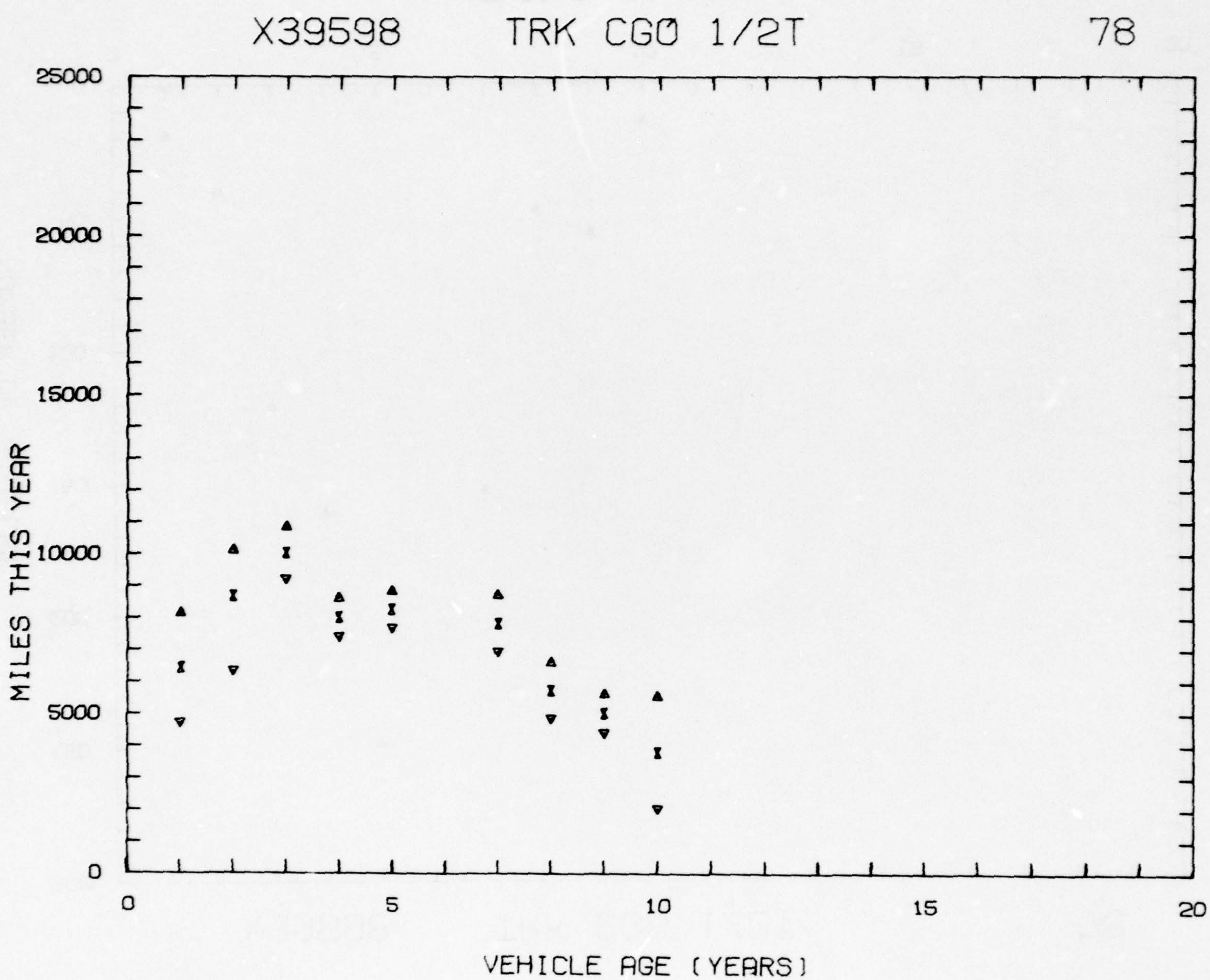
RSD = 14

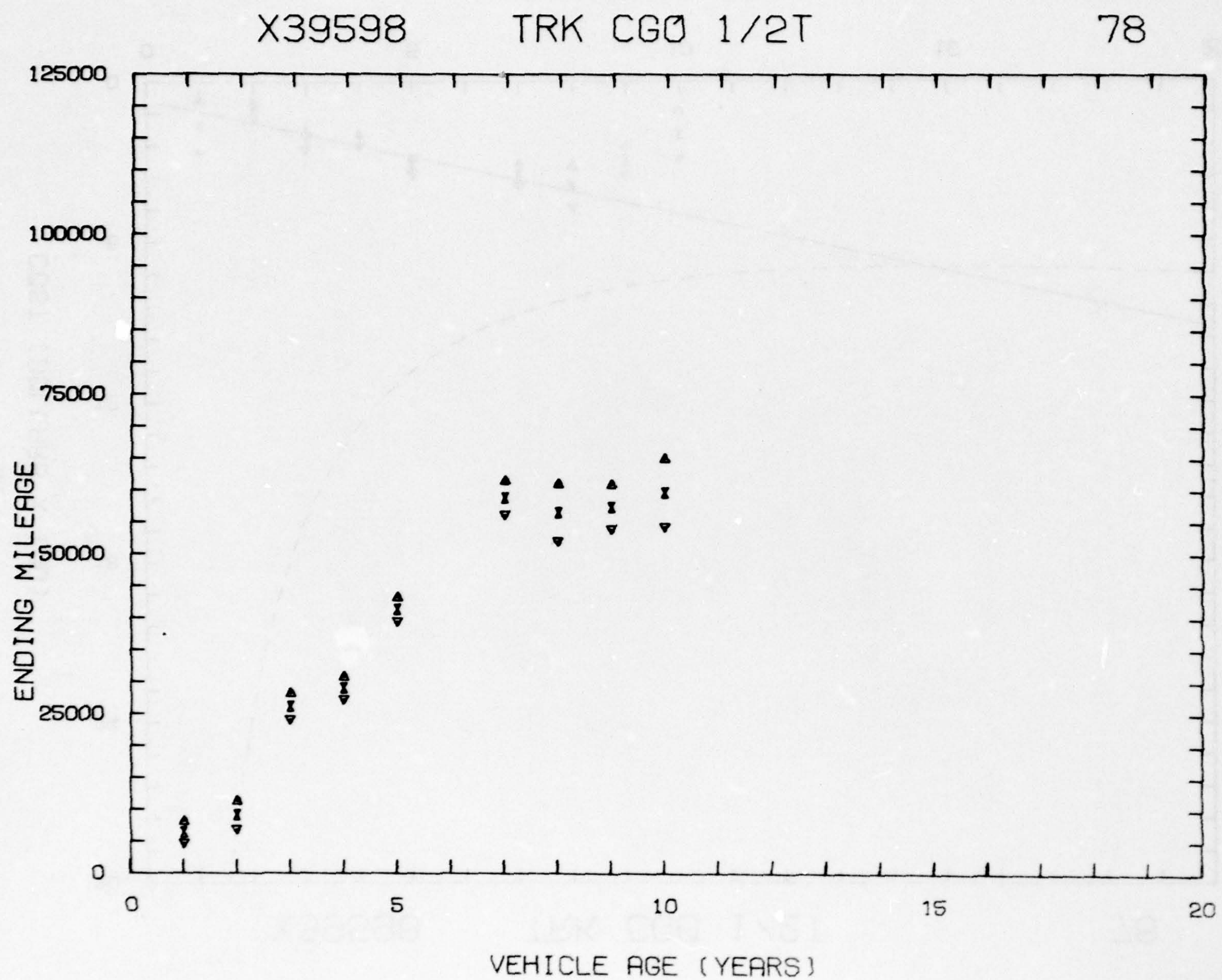
for each 1000 miles more than 8000 add 1.1 hours

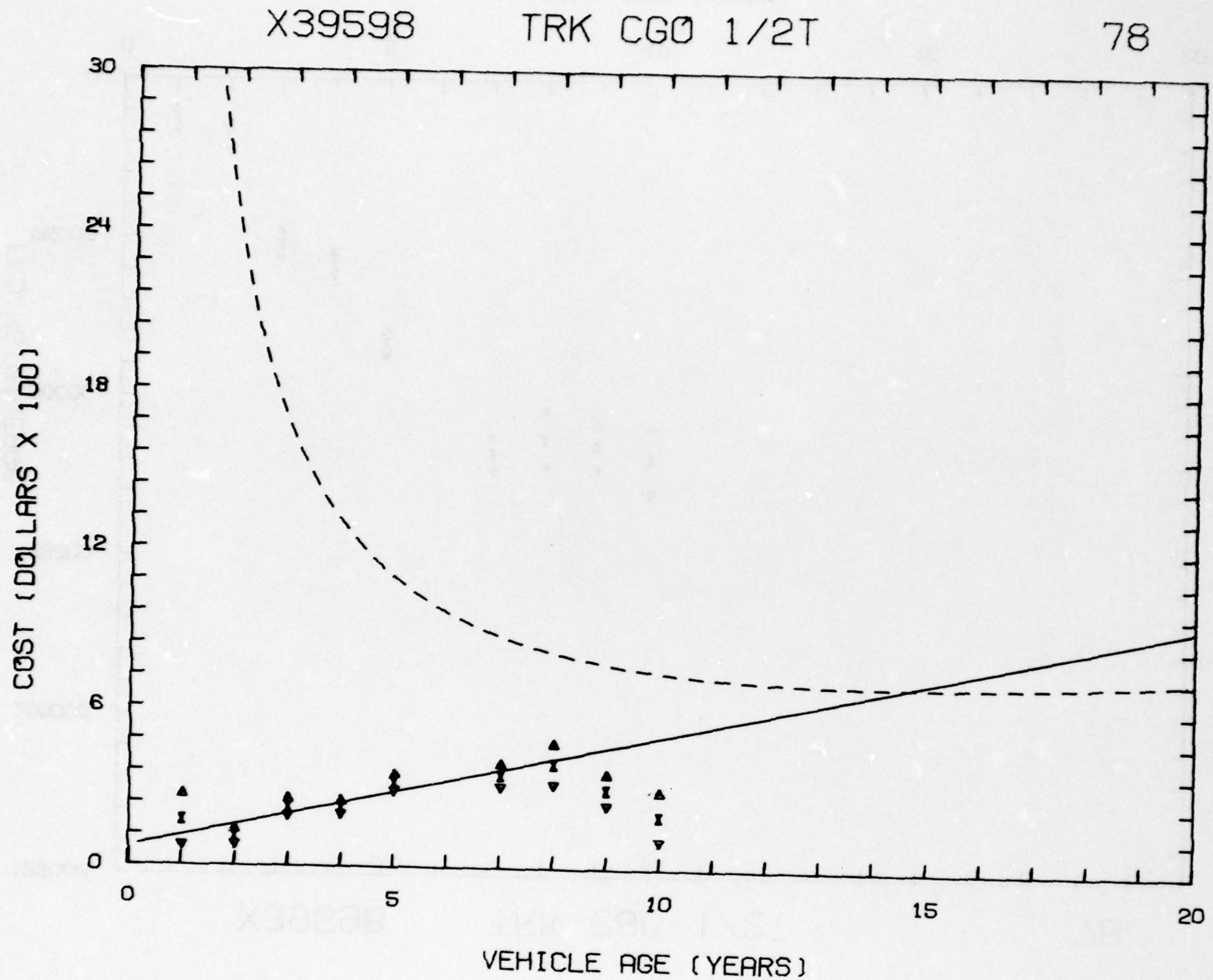
less 8000 subtract 1.1

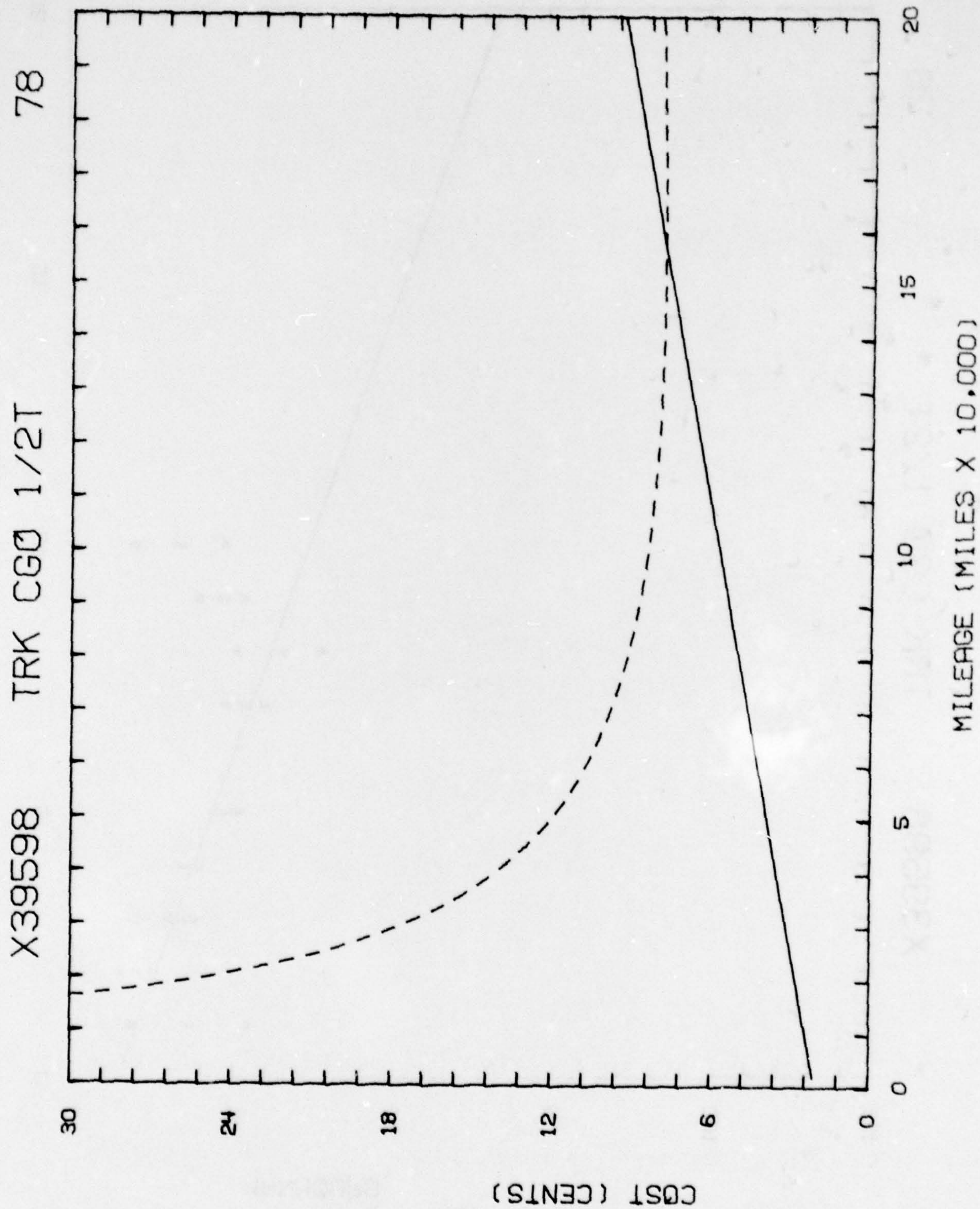
COMMENTS:

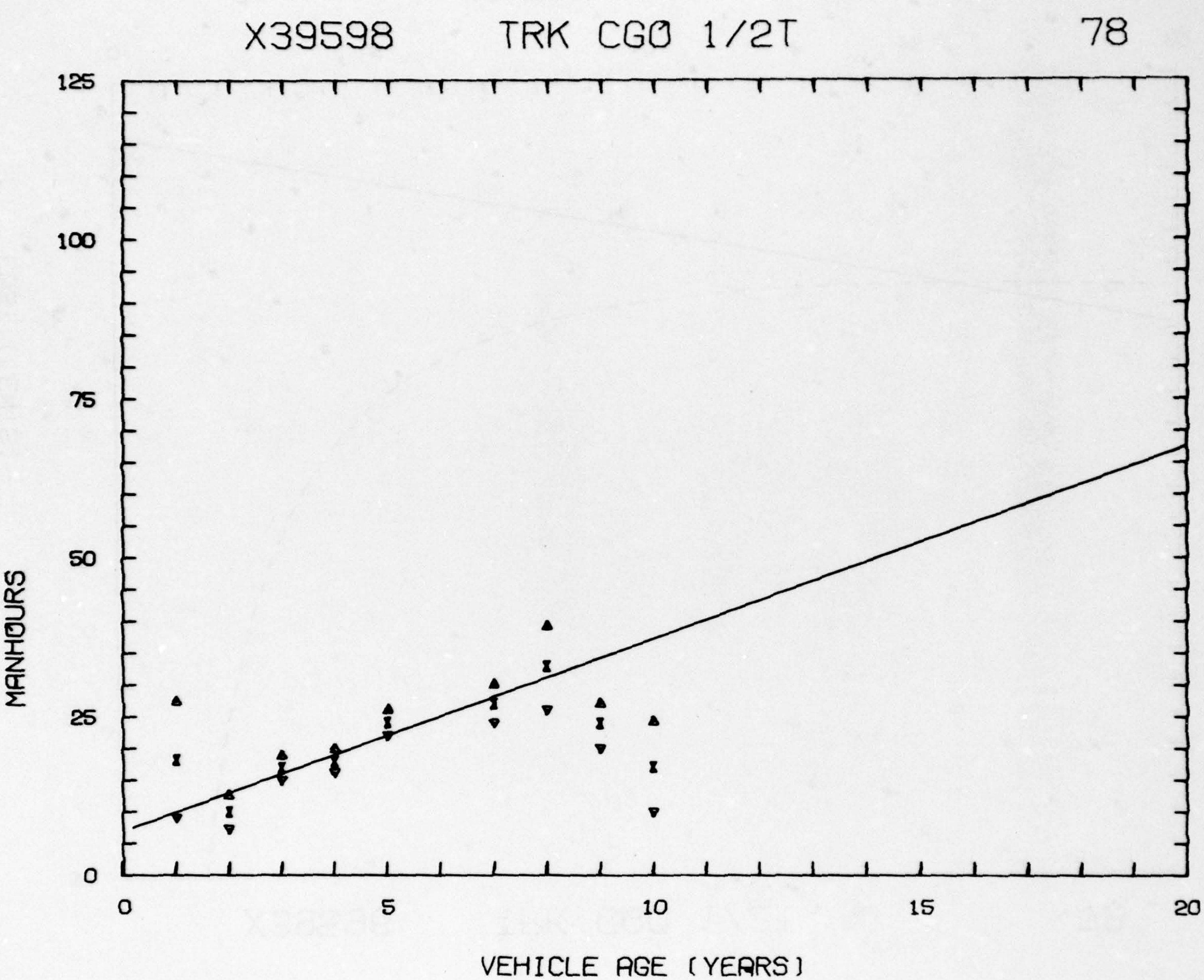

X39598 TRK CGØ 1/2T 78
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20

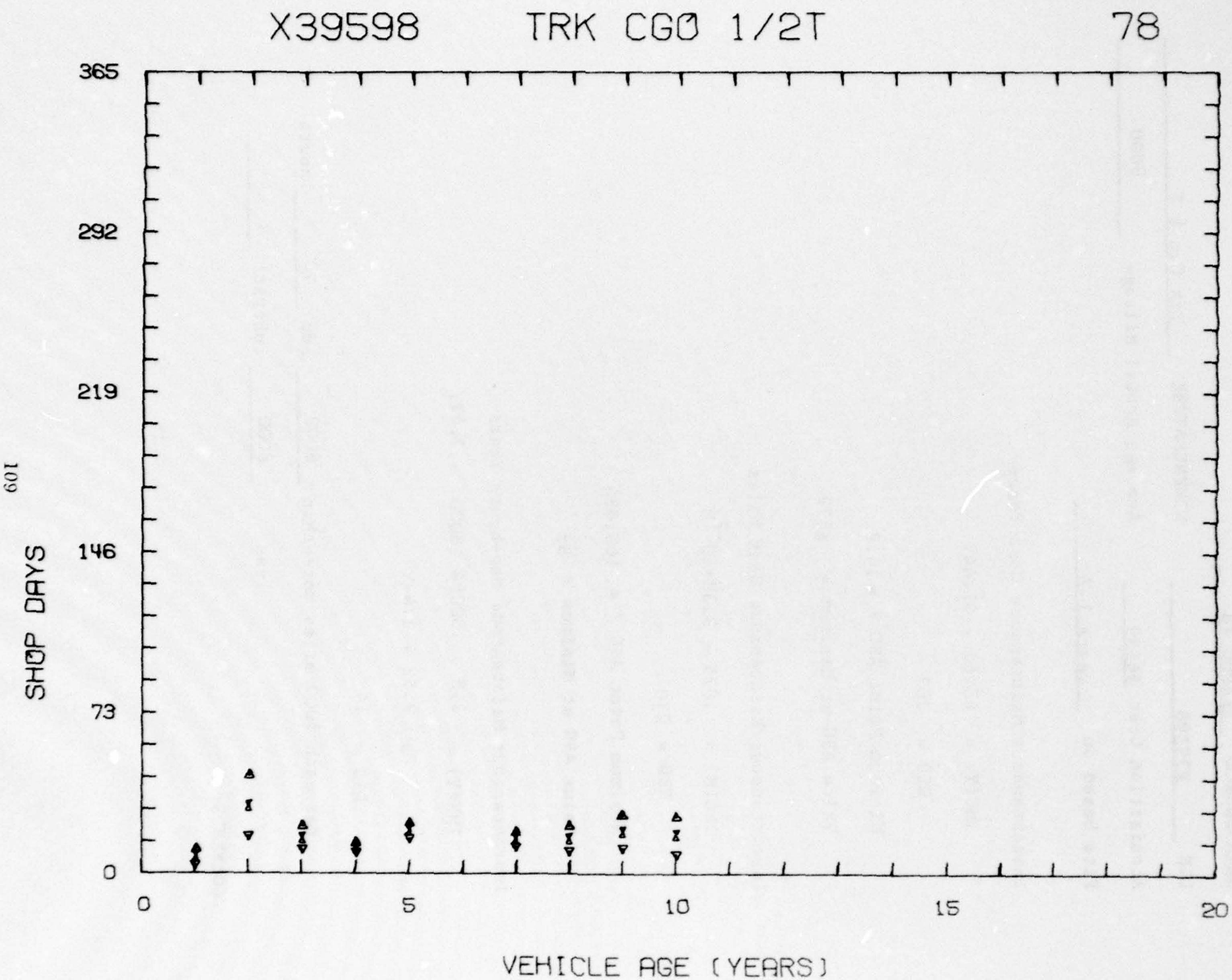

X39598 TRK CGØ 1/2T 78
MILES THIS YEAR
25000
20000
15000
10000
5000
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGØ 1/2T 78
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGO 1/2T 78
COST (DOLLARS X 100)
0
6
12
18
24
30
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGØ 1/2T 78
COST (CENTS)
MILEAGE (MILES X 10,000)
0
6
12
18
24
30
0
5
10
15
20


X39598
TRK CGØ 1/2T
78
MANHOURS
125
100
75
50
25
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGØ 1/2T 78
SHØP DAYS
365
292
219
146
73
0
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 78

LIN X39598 NOMENCLATURE Trk Cgo $\frac{1}{2}$ T

Acquisition Cost $4539 Average Annual Mileage 8000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 65.66 + 41.44Y$

RSD = 207

Minimum Point ASC Y = 14.8

Value ASC at Minimum = $679

Instantaneous Maintenance Cost Miles

$IMC(M) = .025 + 3.38 \cdot 10^{-7} M$

RSD = 210

Minimum Point ASC Y = 163,884

Value ASC at Minimum = 8¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) = 2.8 + .00084\ (8000) + 2.47Y$

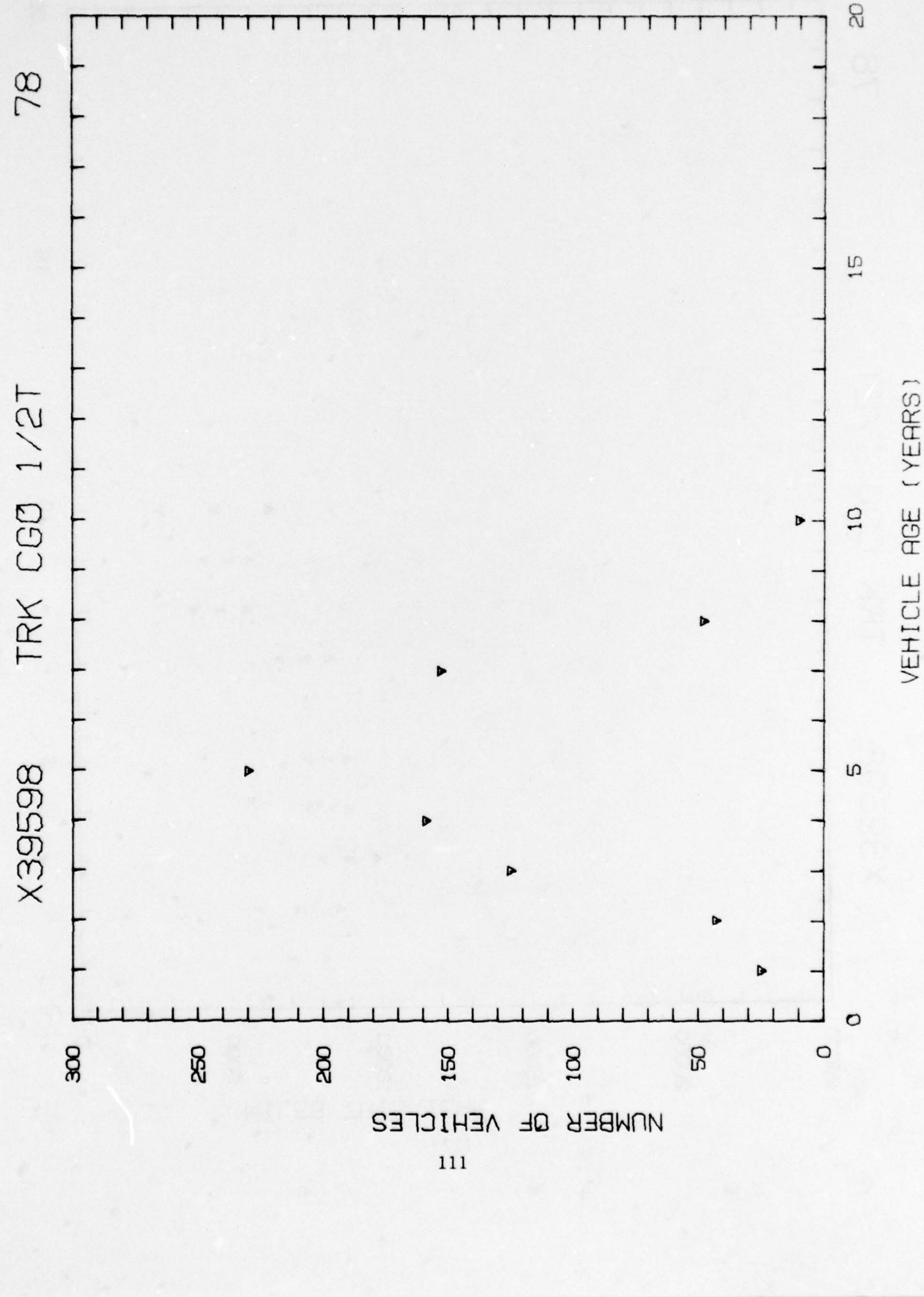
$= 9.52 + 2.47Y$

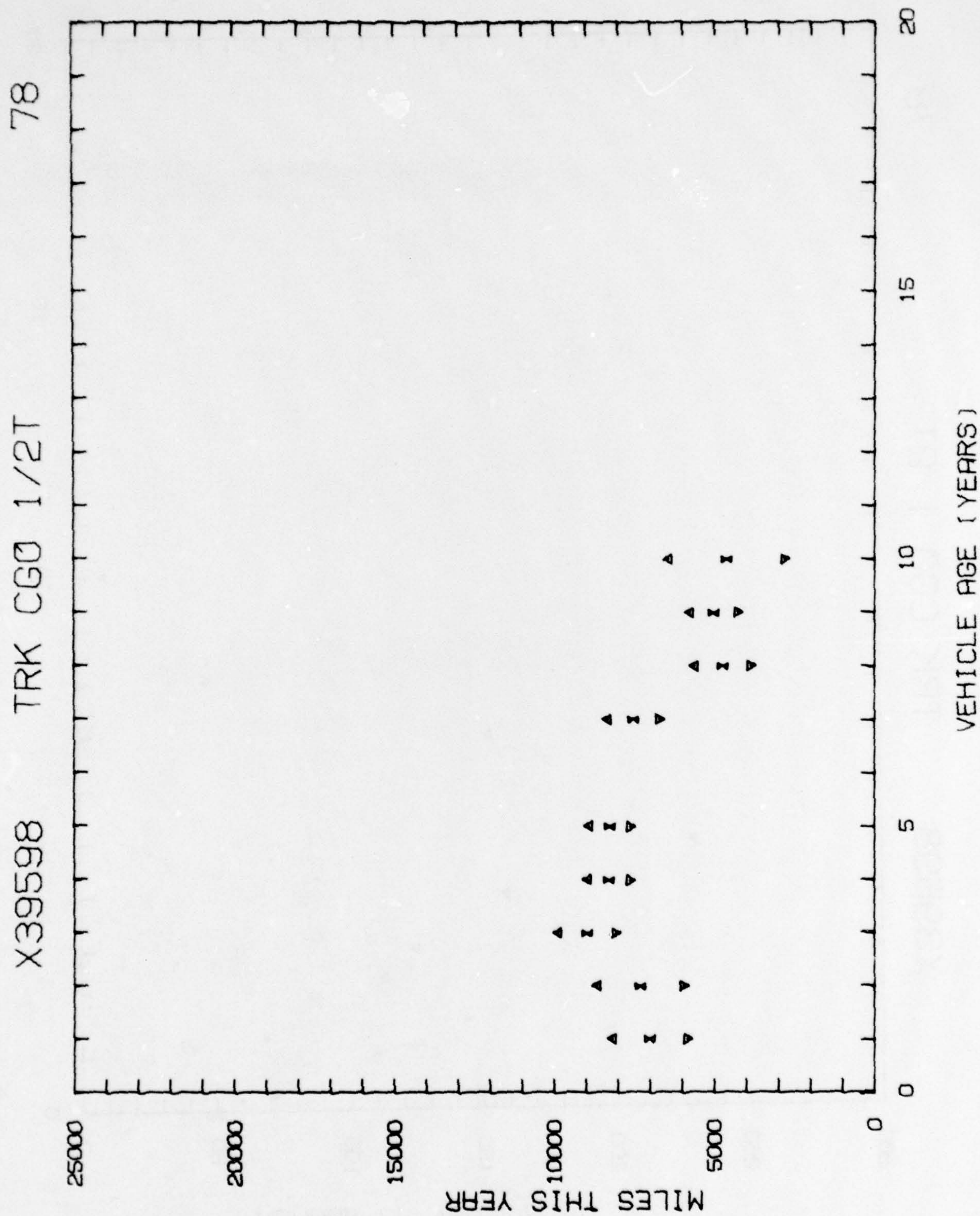
RSD = 14

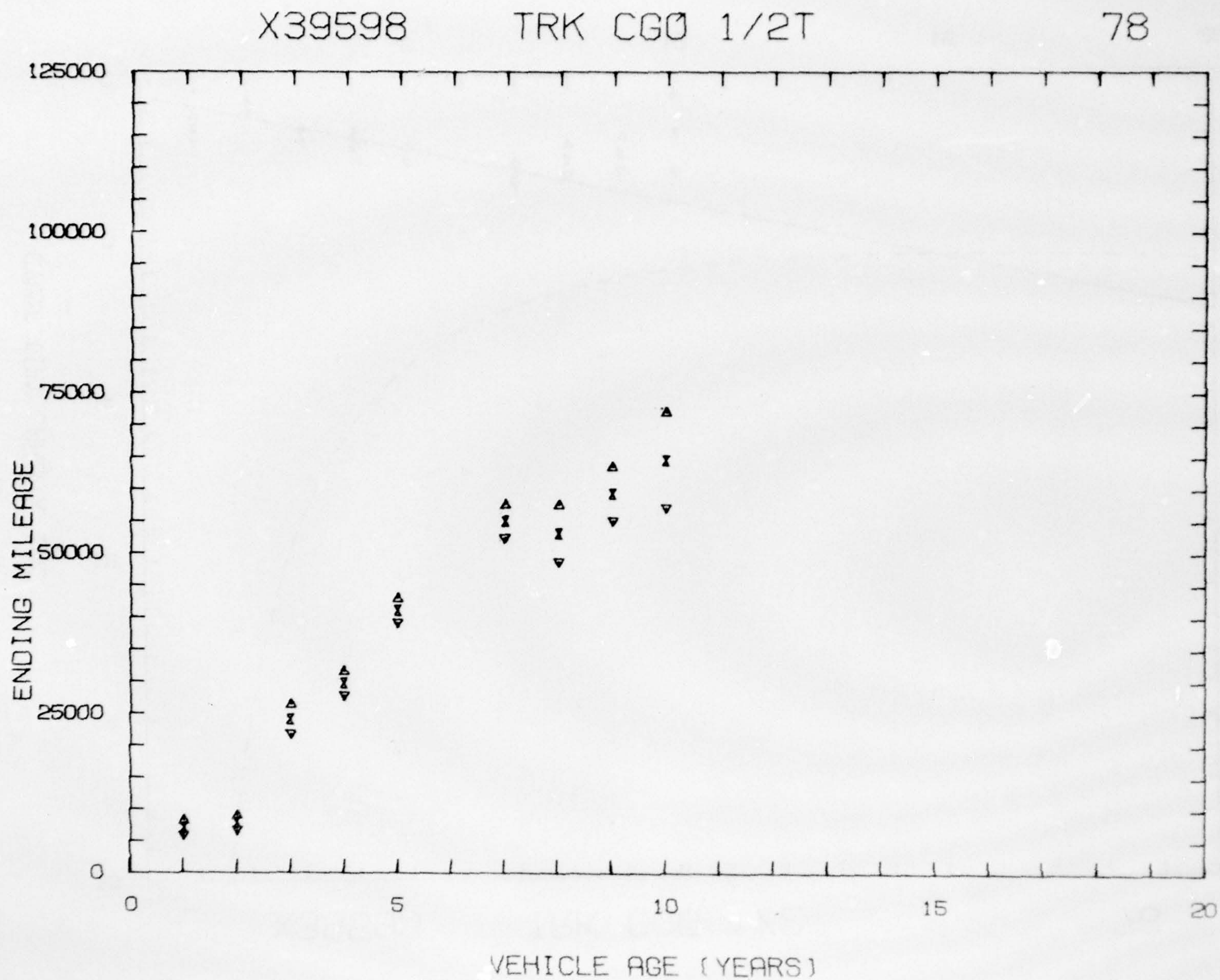
for each 1000 miles more than 8000 add .8 hours

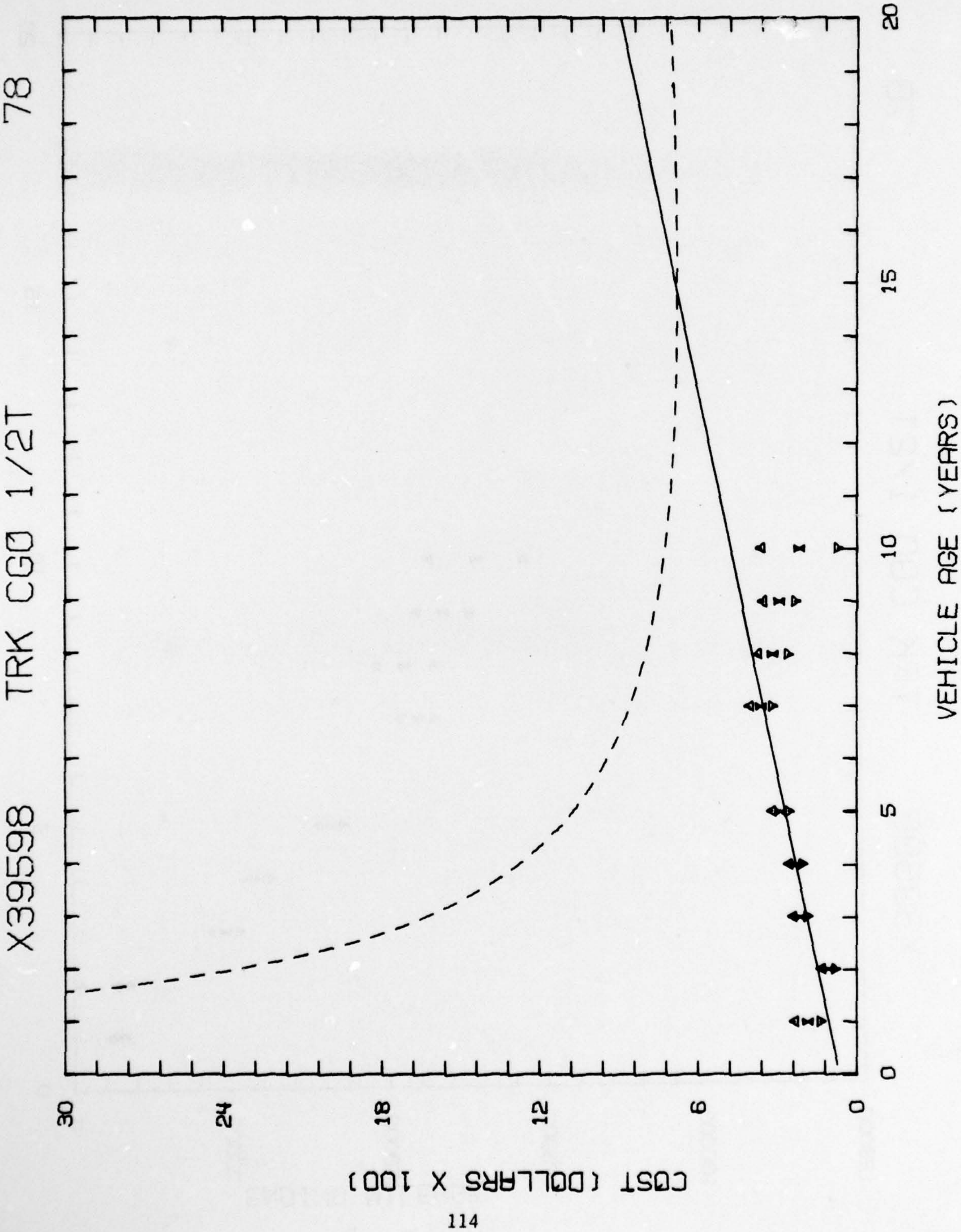
less 8000 subtract .8

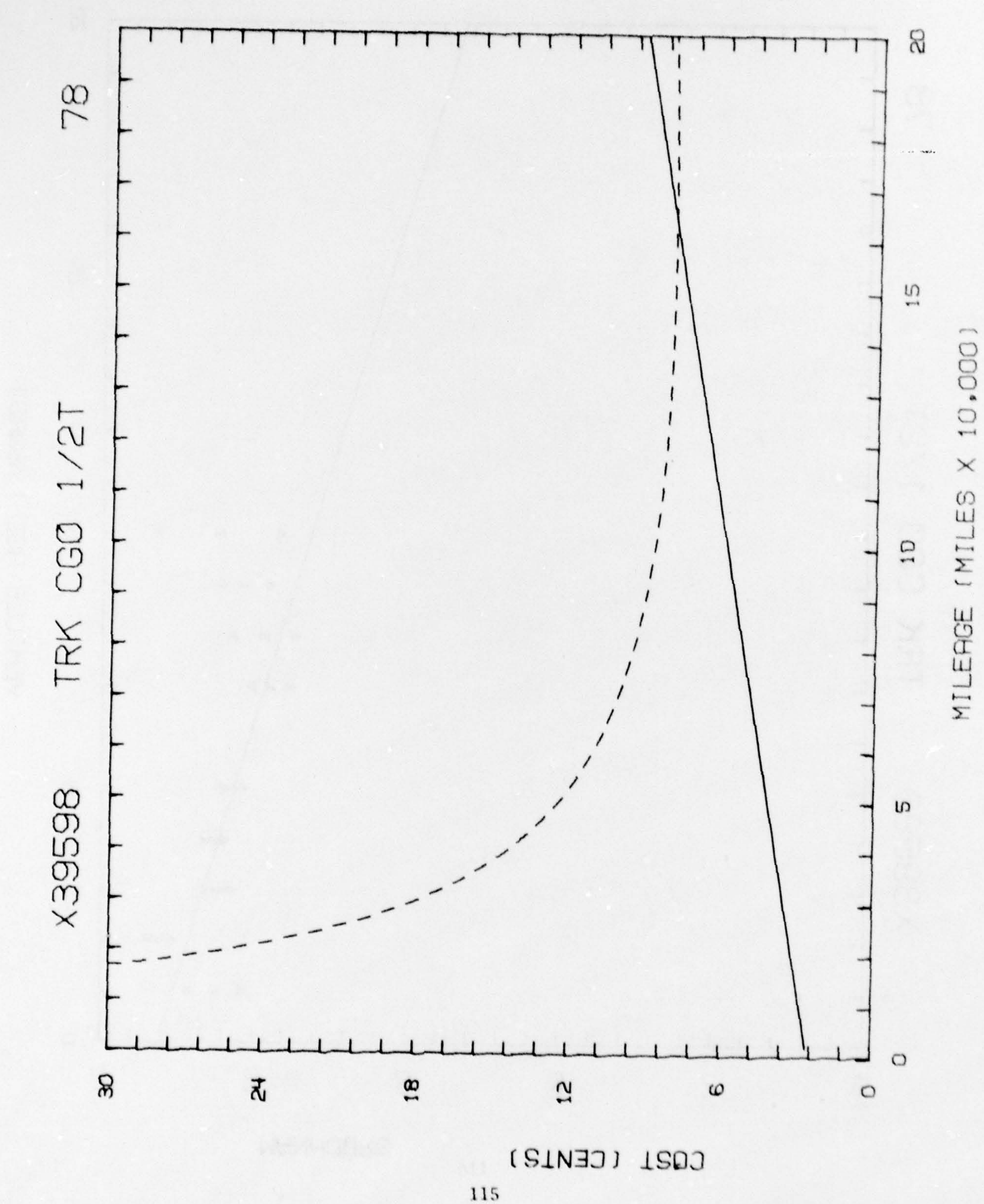
COMMENTS:

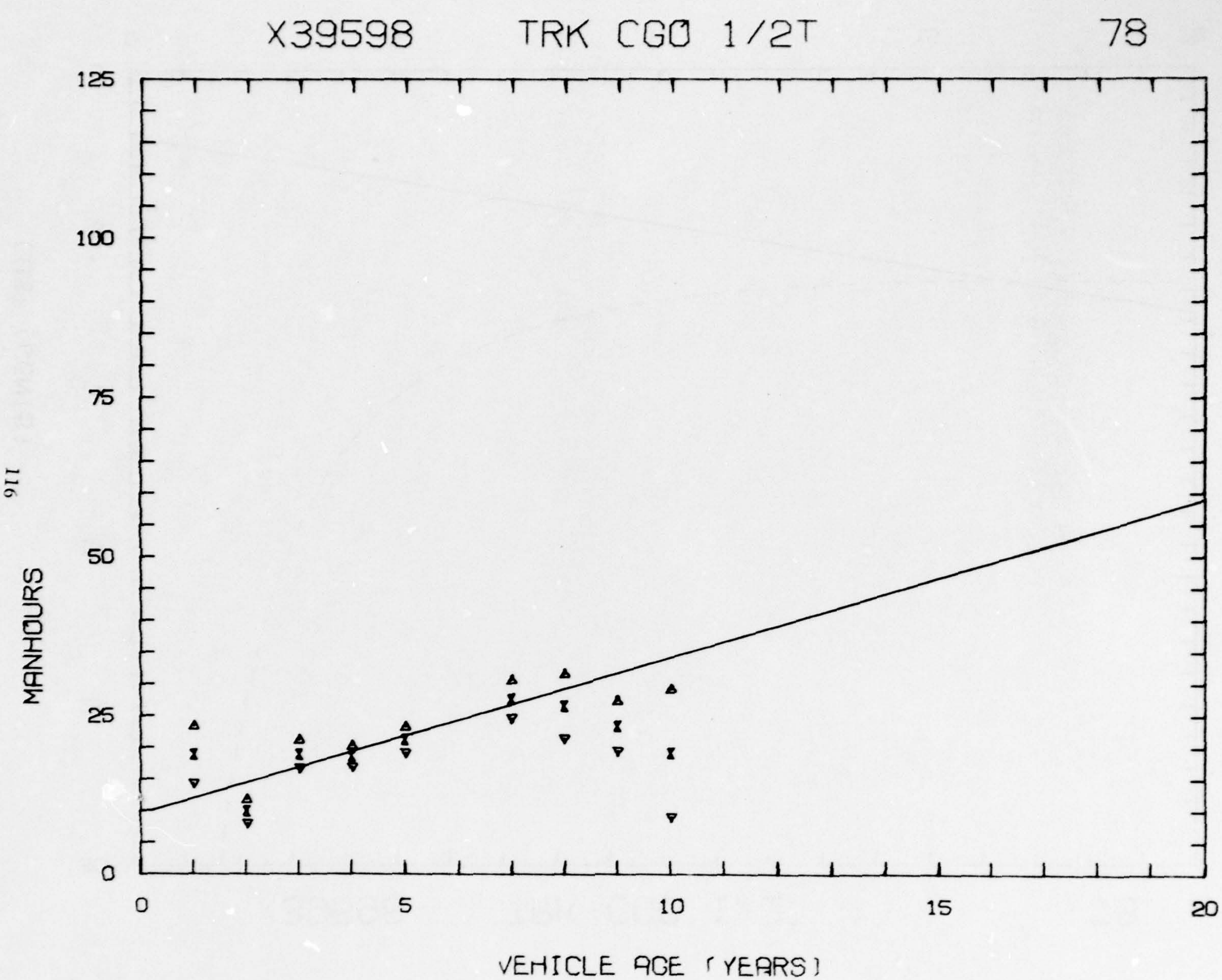

X39598 TRK CGØ 1/2T 78
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20

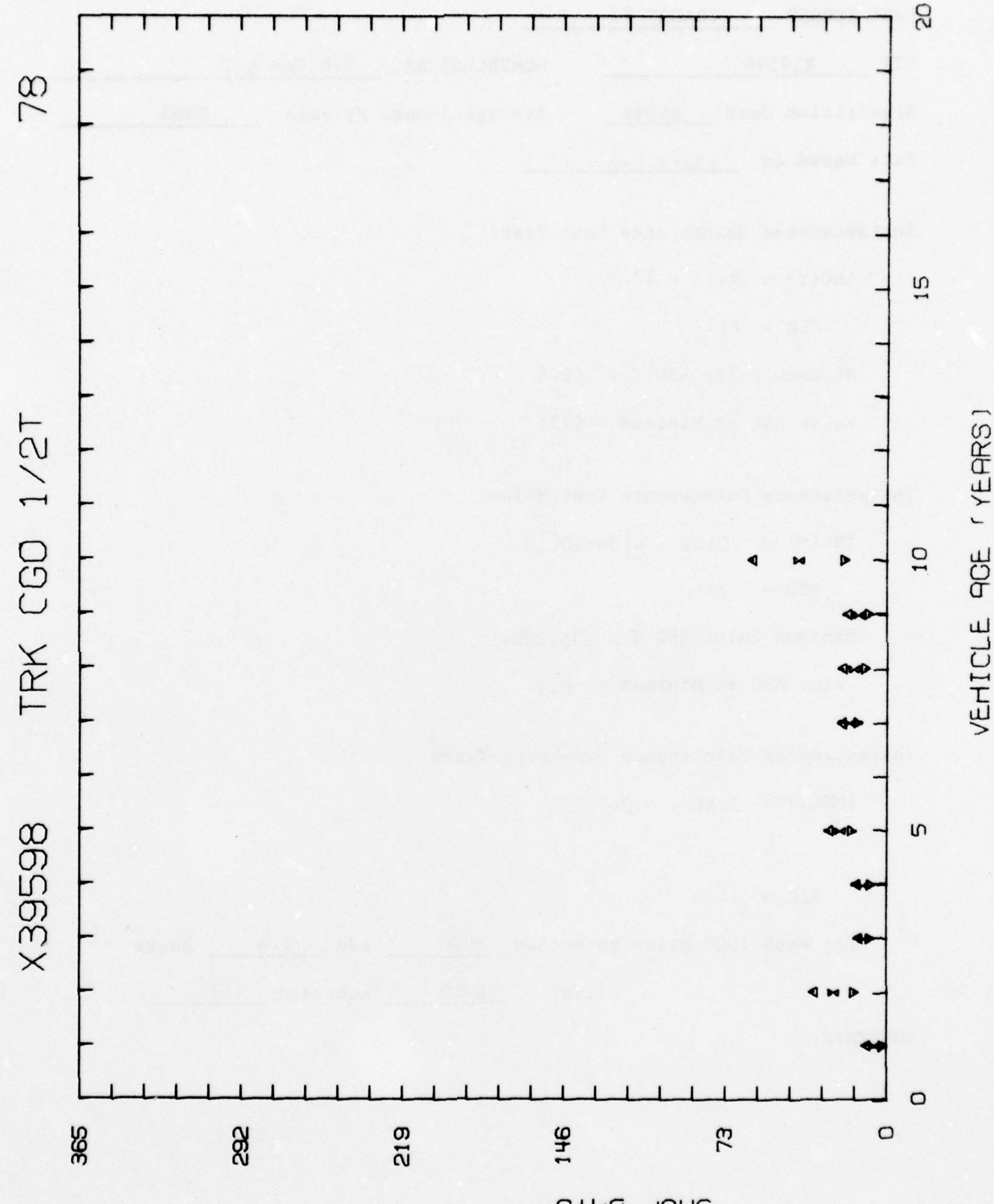

X39598
TRK CG0 1/2T
78
MILES THIS YEAR
25000
20000
15000
10000
5000
0
VEHICLE AGE (YEARS)
0
5
10
15
20


X39598 TRK CGØ 1/2T 78
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGO 1/2T 78
COST (DOLLARS X 100)
VEHICLE AGE (YEARS)
0
6
12
18
24
30
0
5
10
15
20


X39598 TRK CGO 1/2T 78
COST (CENTS)
MILEAGE (MILES X 10,000)
0
6
12
18
24
30
0
5
10
15
20


X39598 TRK CGO 1/2T 78
125
100
75
50
25
0
0
5
10
15
20
MANHOURS
VEHICLE AGE (YEARS)


X39598 TRK CGO 1/2T 78
SHOP DAYS
365
292
219
146
73
0
VEHICLE AGE (YEARS)
0
5
10
15
20

DATA SOURCE TRADOC 77

LIN X39598 NOMENCLATURE Trk Cgo ½ T

Acquisition Cost $4539 Average Annual Mileage 8000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 9.77 + 57.30Y$

RSD = 213

Minimum Point ASC Y = 12.6

Value ASC at Minimum = $731

Instantaneous Maintenance Cost Miles

$IMC(M) = .0159 + 4.96 \cdot 10^{-7} M$

RSD = 215

Minimum Point ASC Y = 135,286

Value ASC at Minimum = 8.3

Instantaneous Maintenance Man-hours Years

$IMH(Y) = 2.56 + 4.34Y$

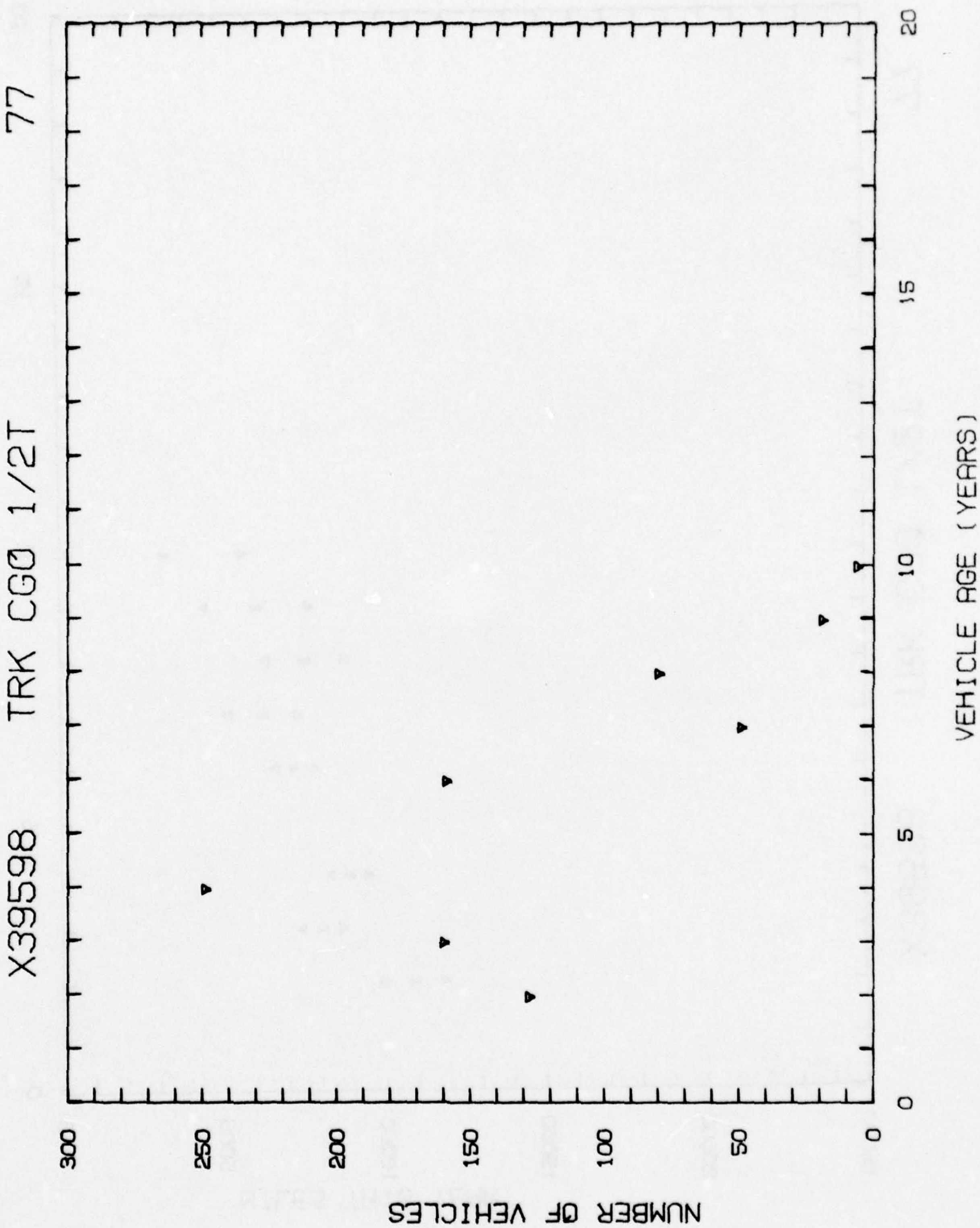
=

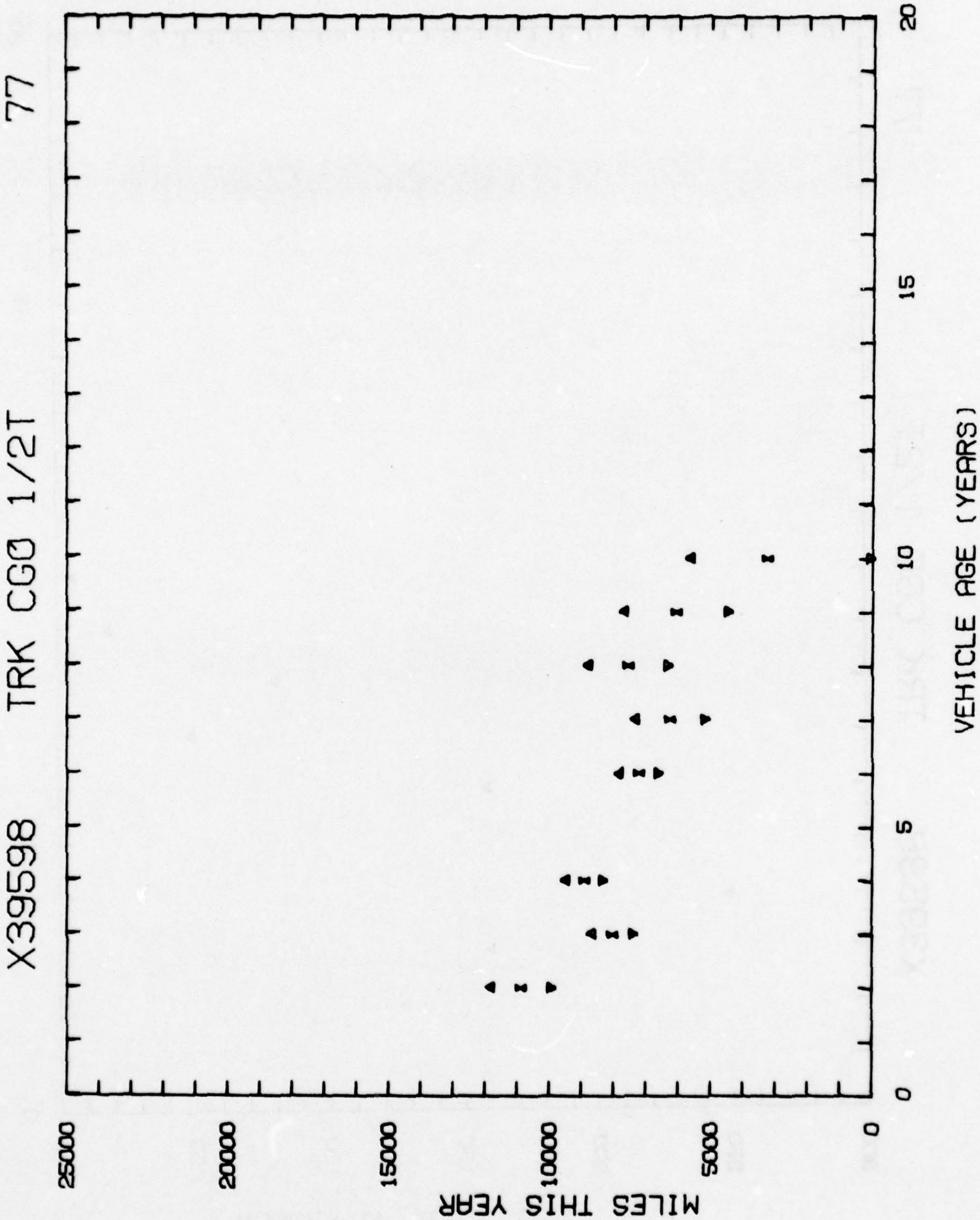
RSD = 14.3

for each 1000 miles more than 8000 add 1.3 hours

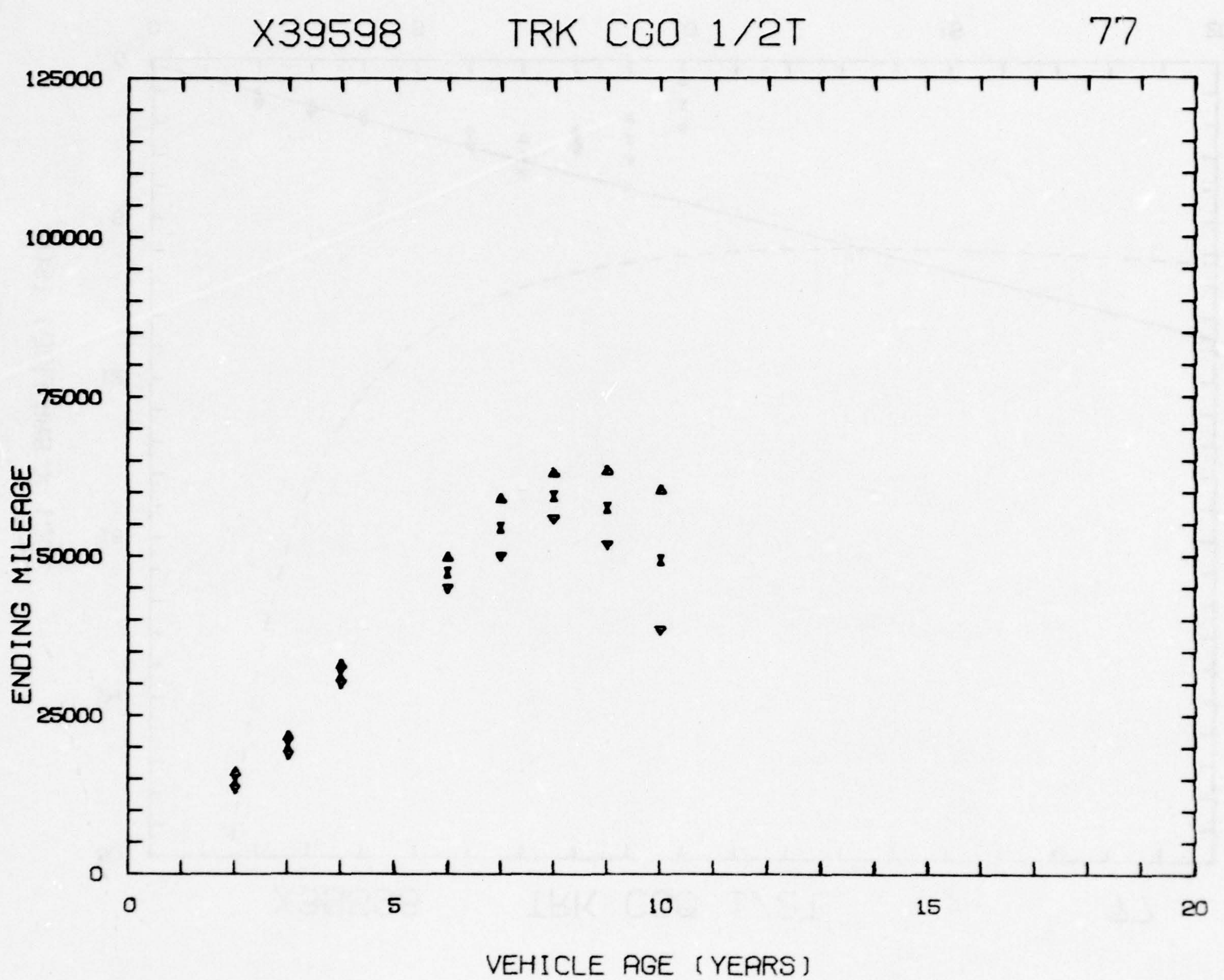
less 8000 subtract 1.3

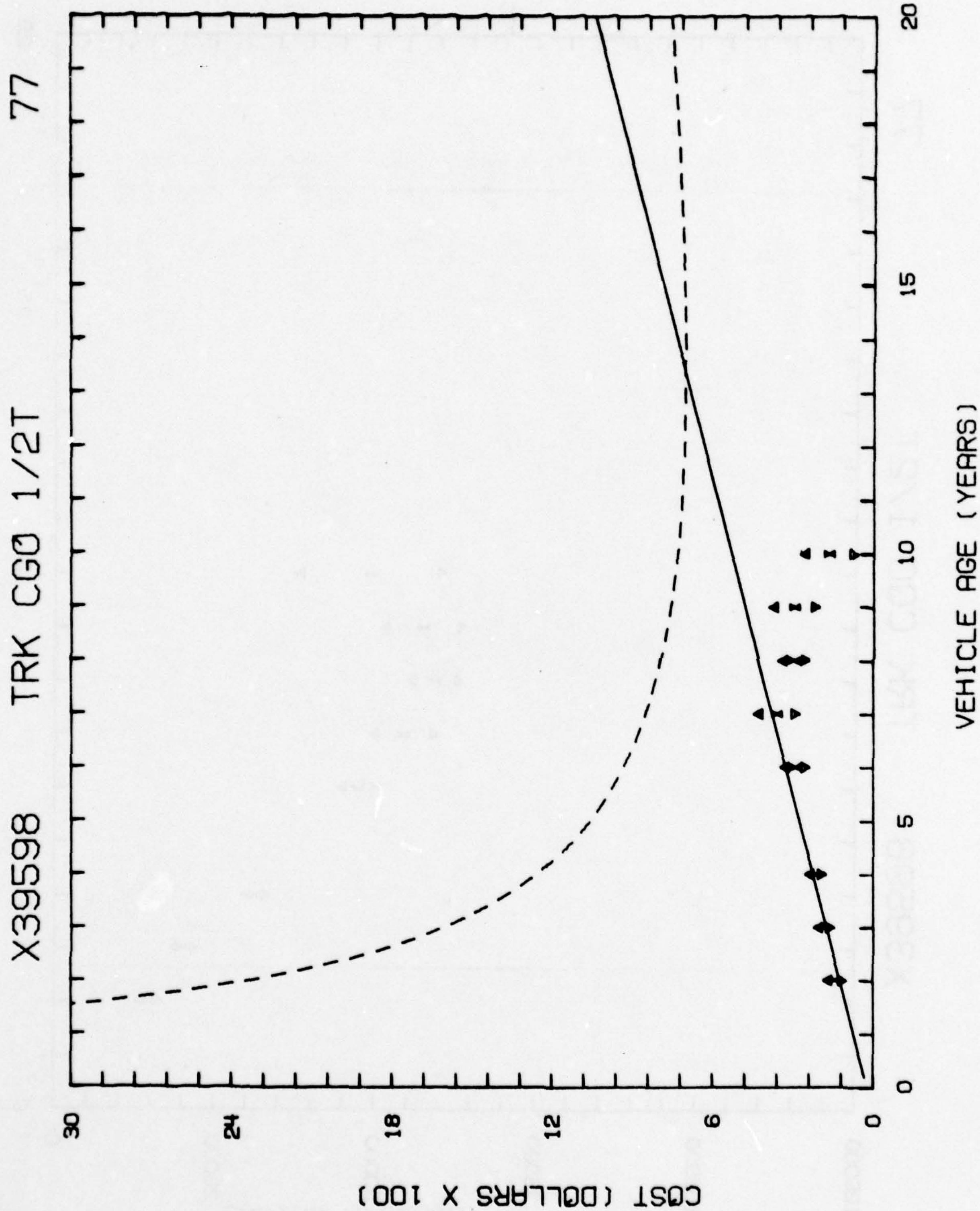
COMMENTS:


X39598 TRK CGØ 1/2T 77
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20

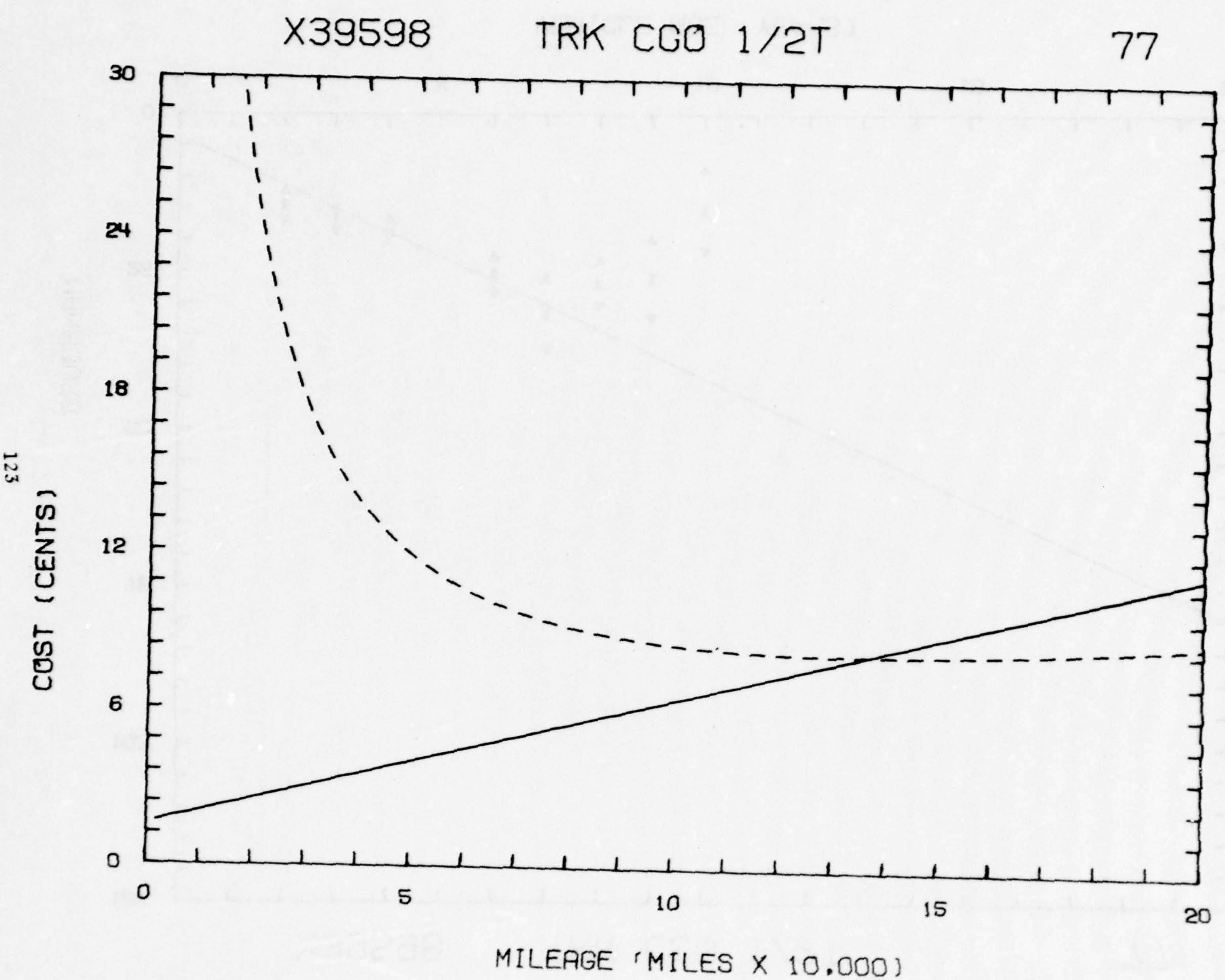


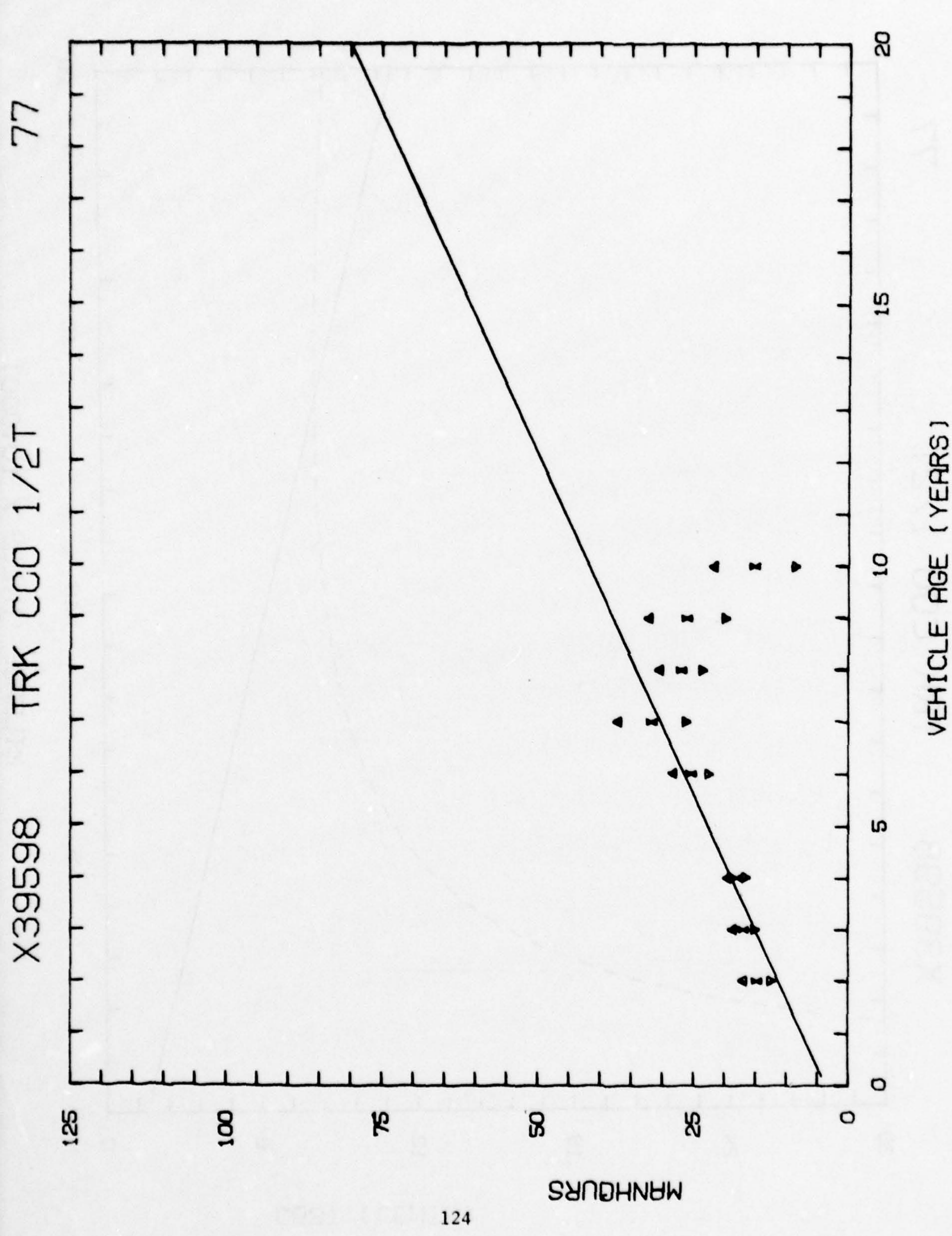
X39598 TRK CGO 1/2T 77
MILES THIS YEAR
25000
20000
15000
10000
5000
0
0
5
10
15
20
VEHICLE AGE (YEARS)

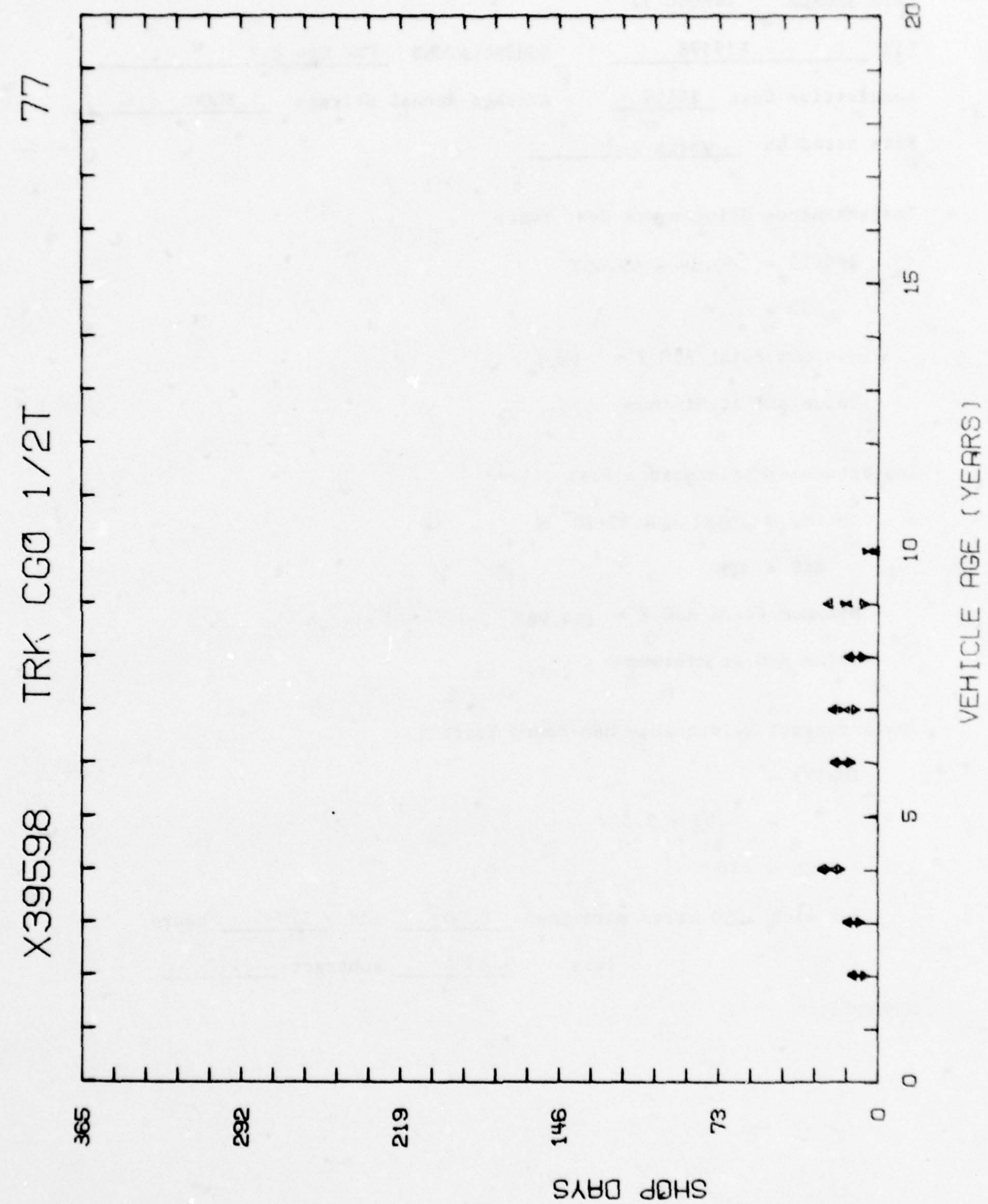

X39598
TRK CGO 1/2T
77
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)



X39598
TRK CGO 1/2T
77
COST (DOLLARS X 100)
VEHICLE AGE (YEARS)
0
6
12
18
24
30
0
5
10
15
20


X39598
TRK CGO 1/2T
77
30
24
18
12
6
0
COST (CENTS)
0
5
10
15
20
MILEAGE (MILES X 10,000)


X39598 TRK CCO 1/2T 77
MANHOURS
0
25
50
75
100
125
VEHICLE AGE (YEARS)
0
5
10
15
20


X39598 TRK CG0 1/2T 77
SHOP DAYS
365
292
219
146
73
0
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN X39598 NOMENCLATURE Trk Cgo ½ T

Acquisition Cost $4539 Average Annual Mileage 8000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 50.39 + 48.05Y$

RSD = 227

Minimum Point ASC Y = 13.7

Value ASC at Minimum = $711

Instantaneous Maintenance Cost Miles

$IMC(M) = .0181 + 4.32 \cdot 10^{-7} M$

RSD = 226

Minimum Point ASC Y = 144,962

Value ASC at Minimum = 8.1¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

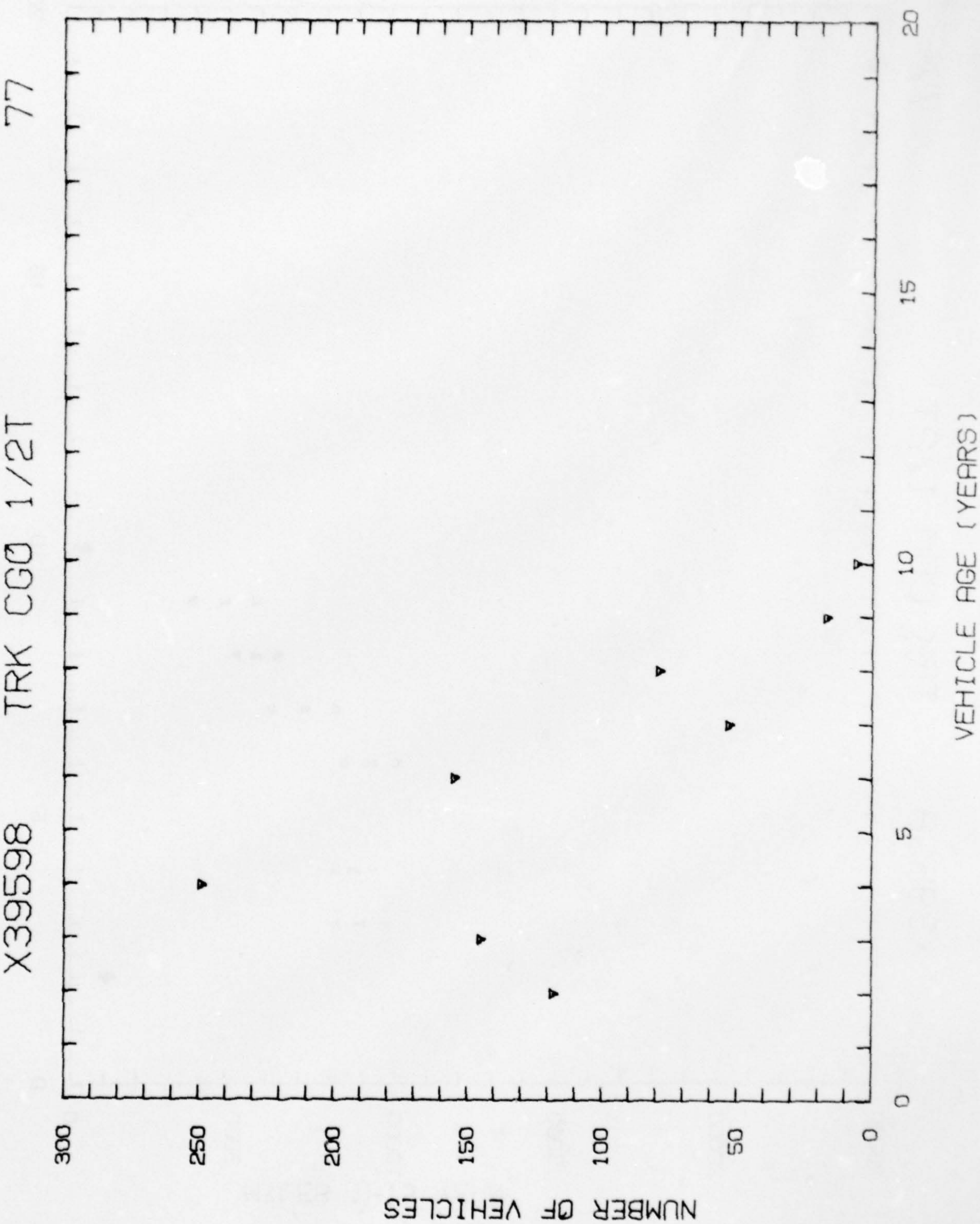
$= 4.88 + 3.52Y$

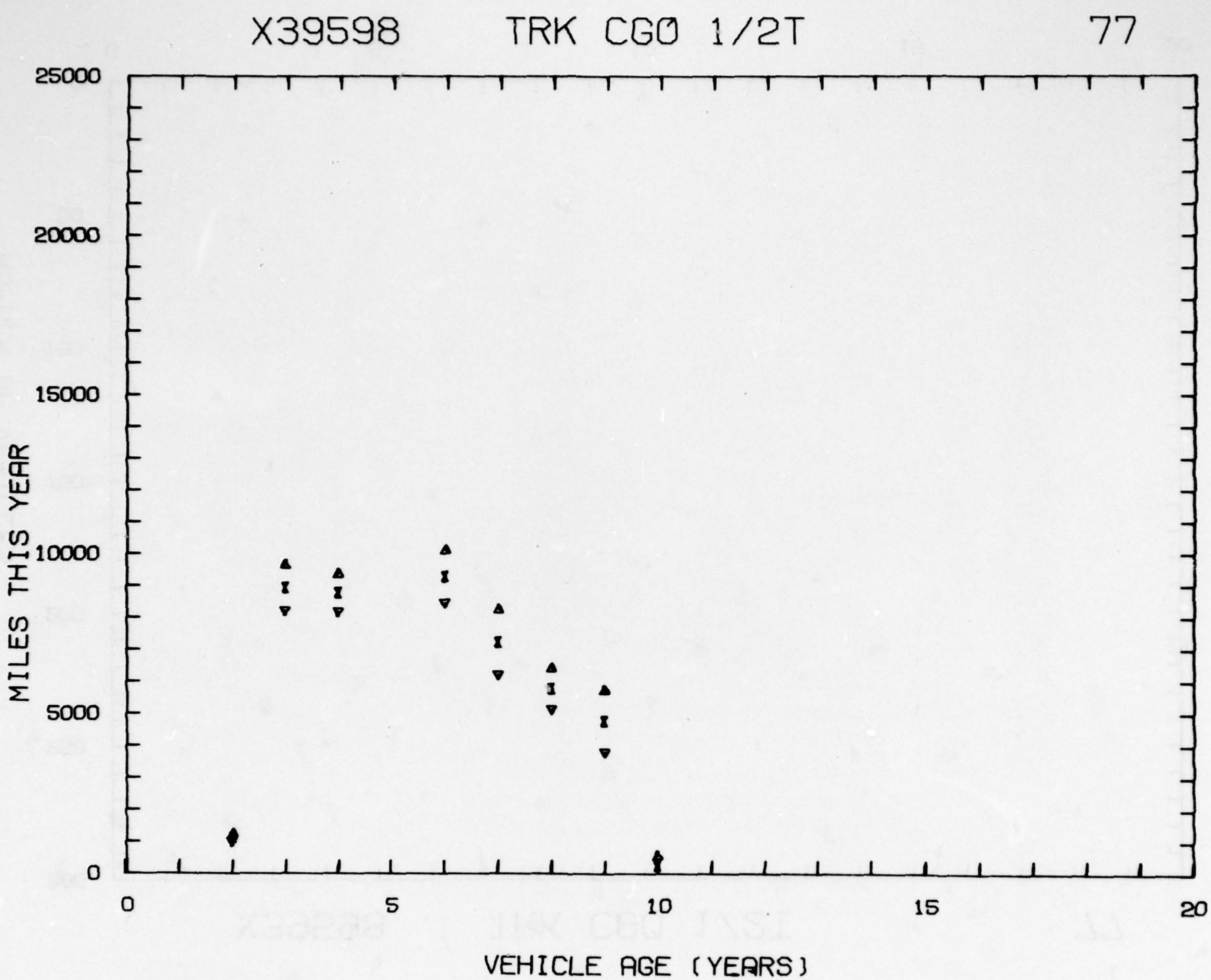
RSD = 16

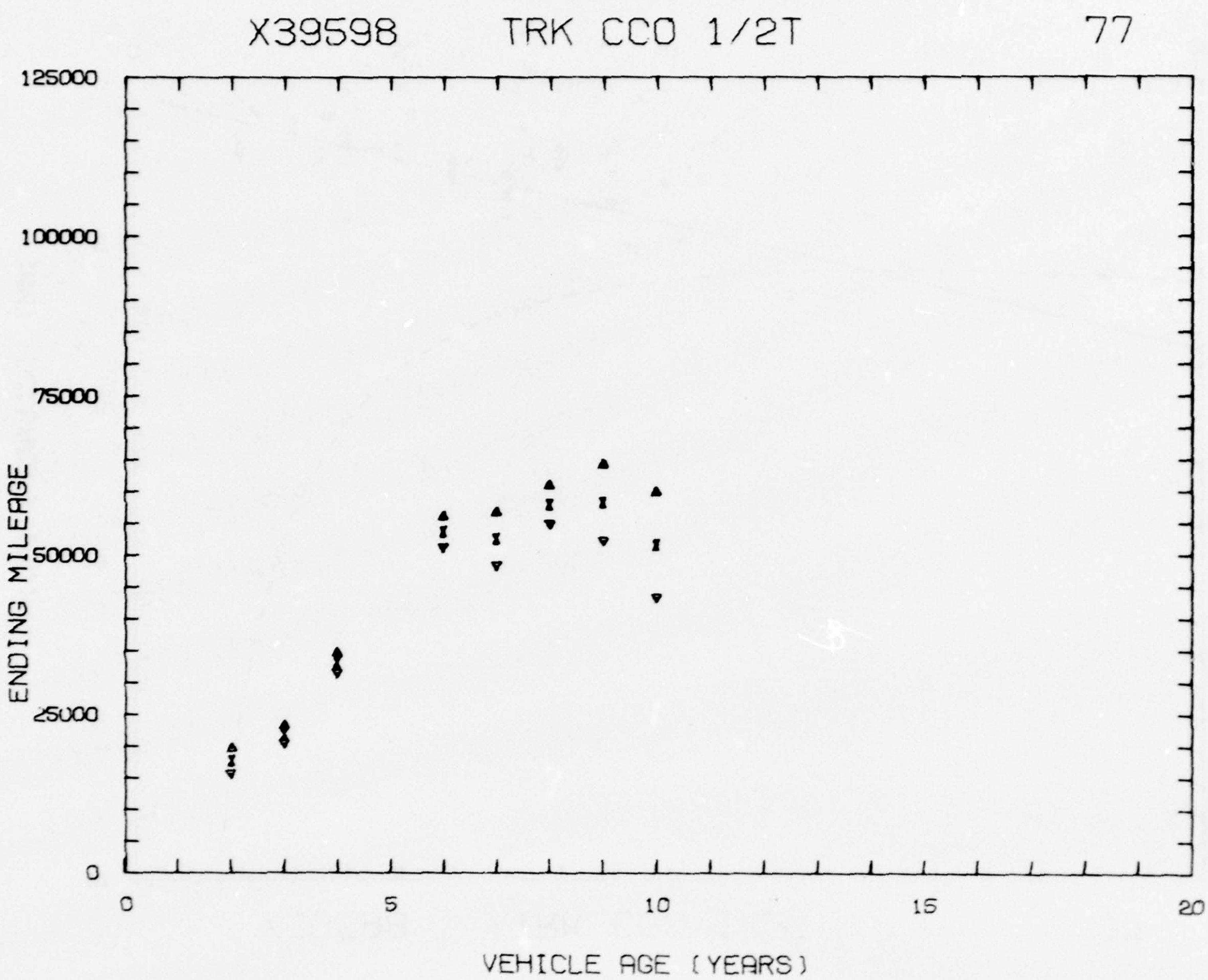
for each 1000 miles more than 8000 add 1.0 hours

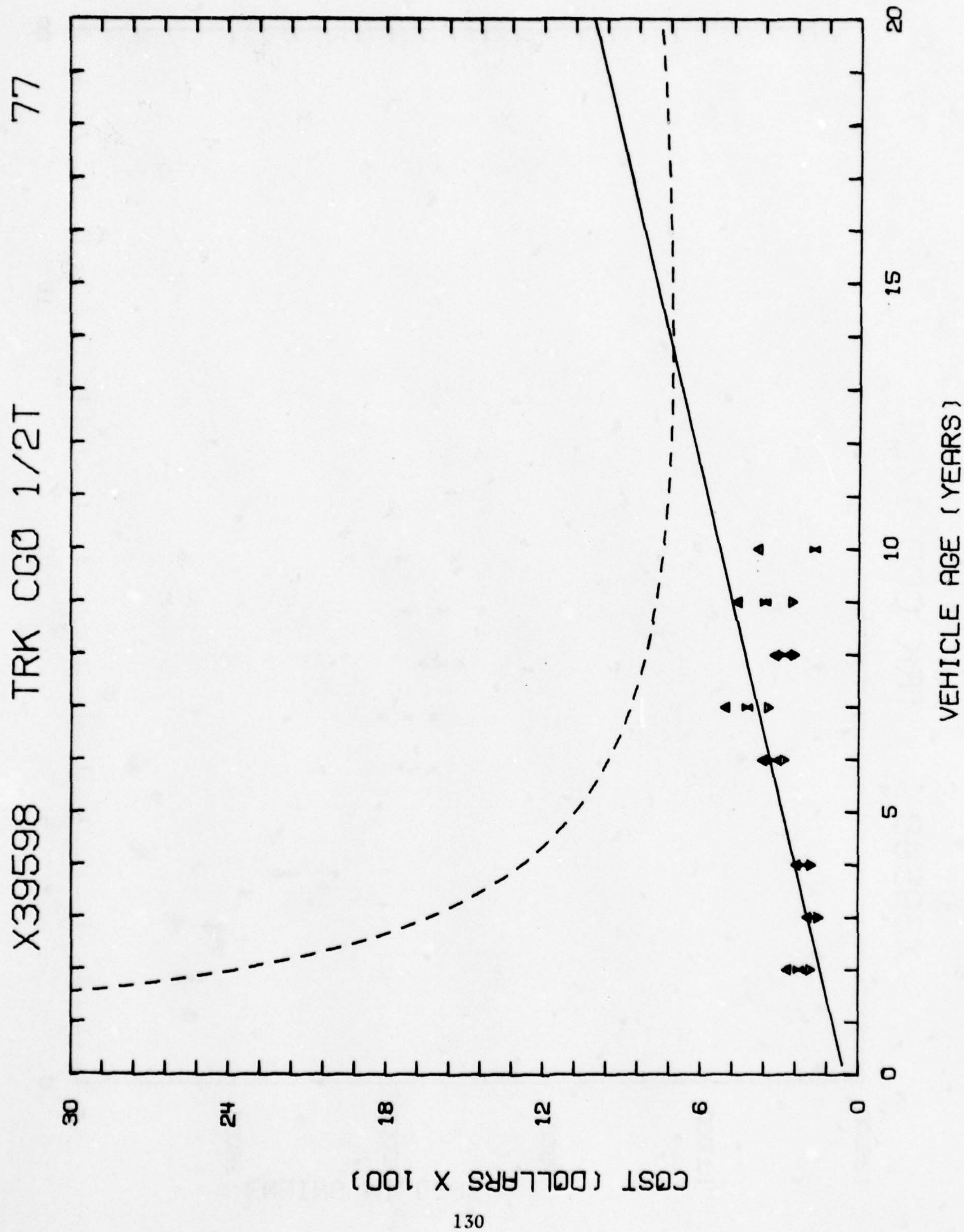
less 8000 subtract 1.0

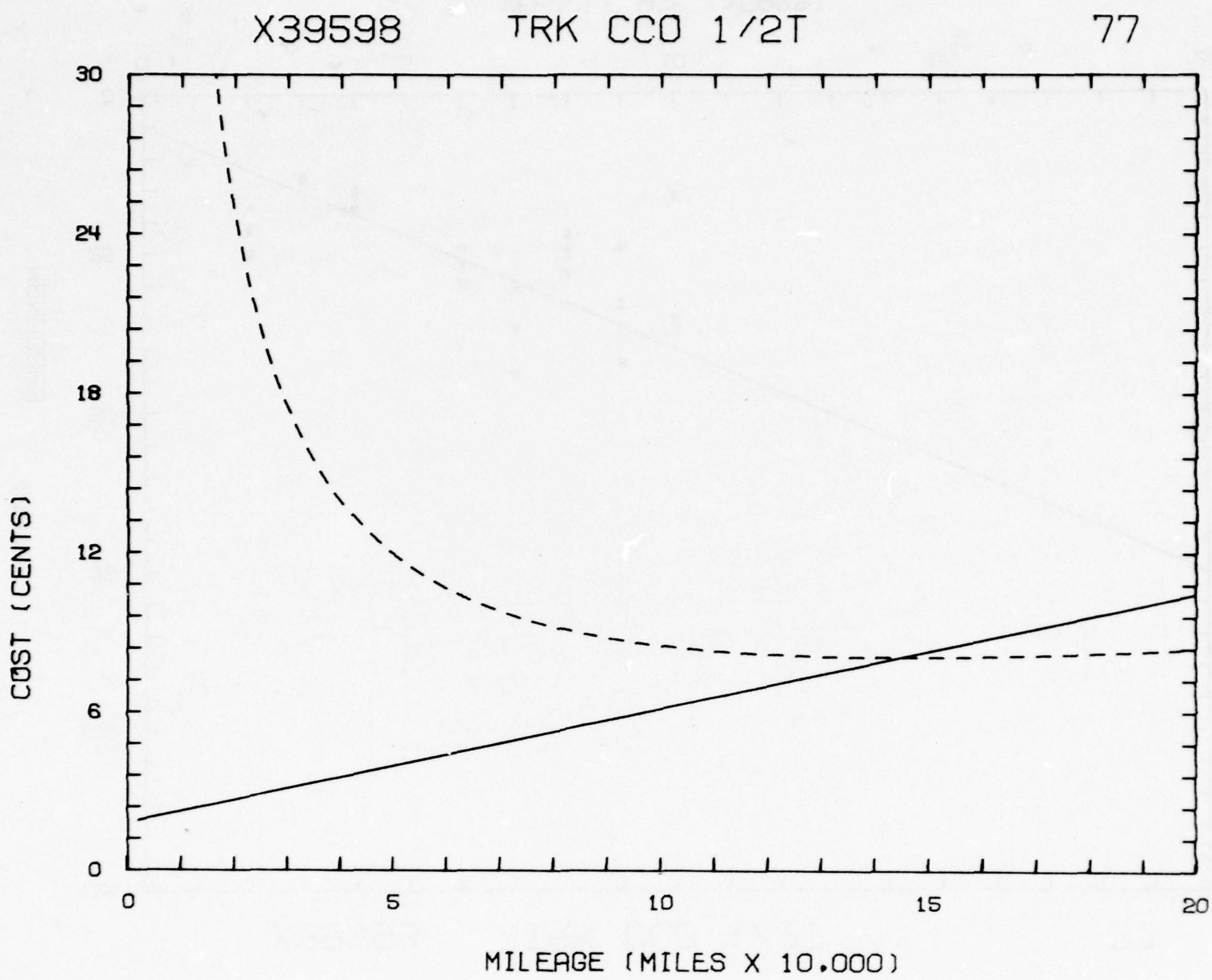
COMMENTS:

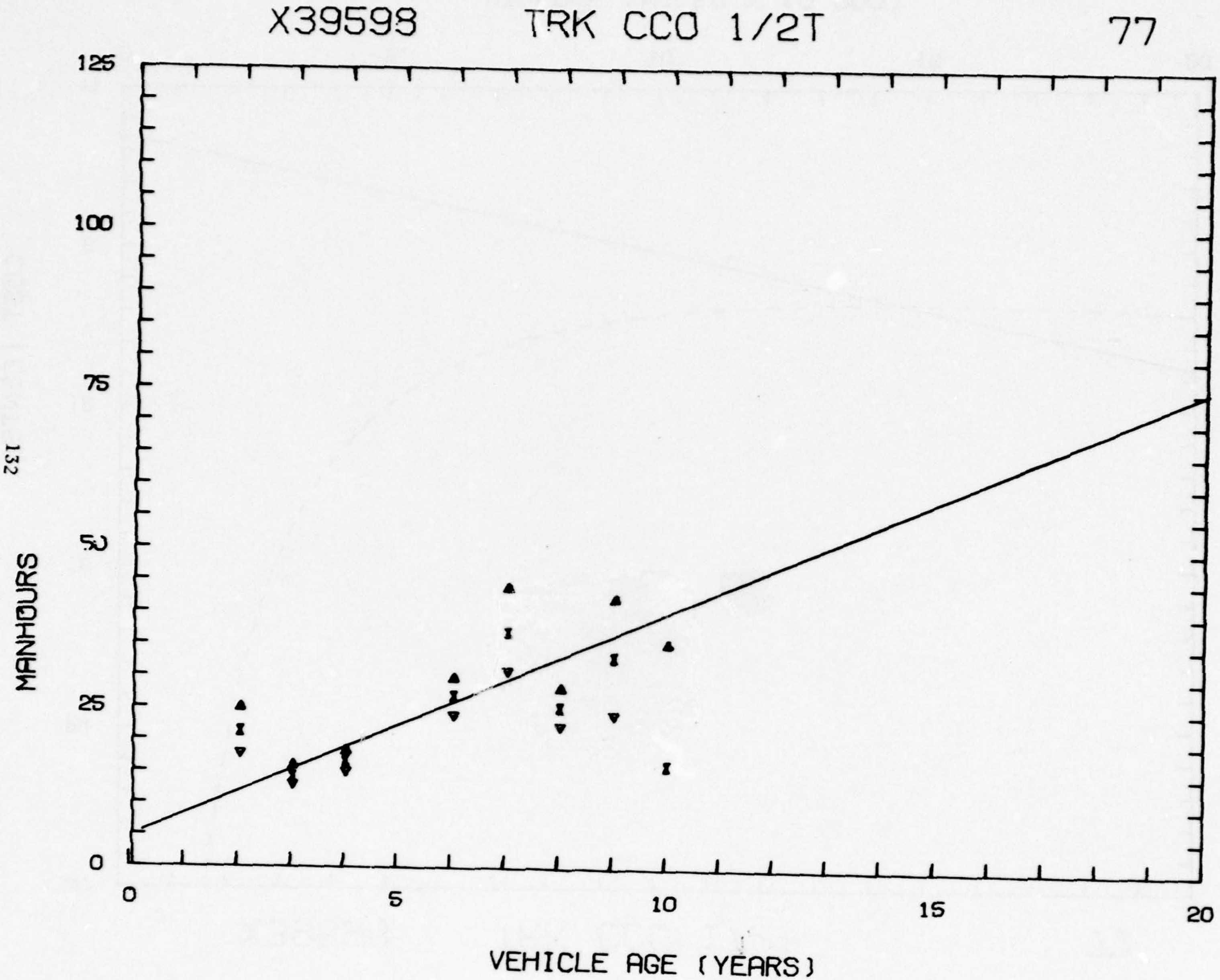

X39598 TRK CGØ 1/2T 77
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20


X39598 TRK CGO 1/2T 77
MILES THIS YEAR
25000
20000
15000
10000
5000
0
0
5
10
15
20
VEHICLE AGE (YEARS)

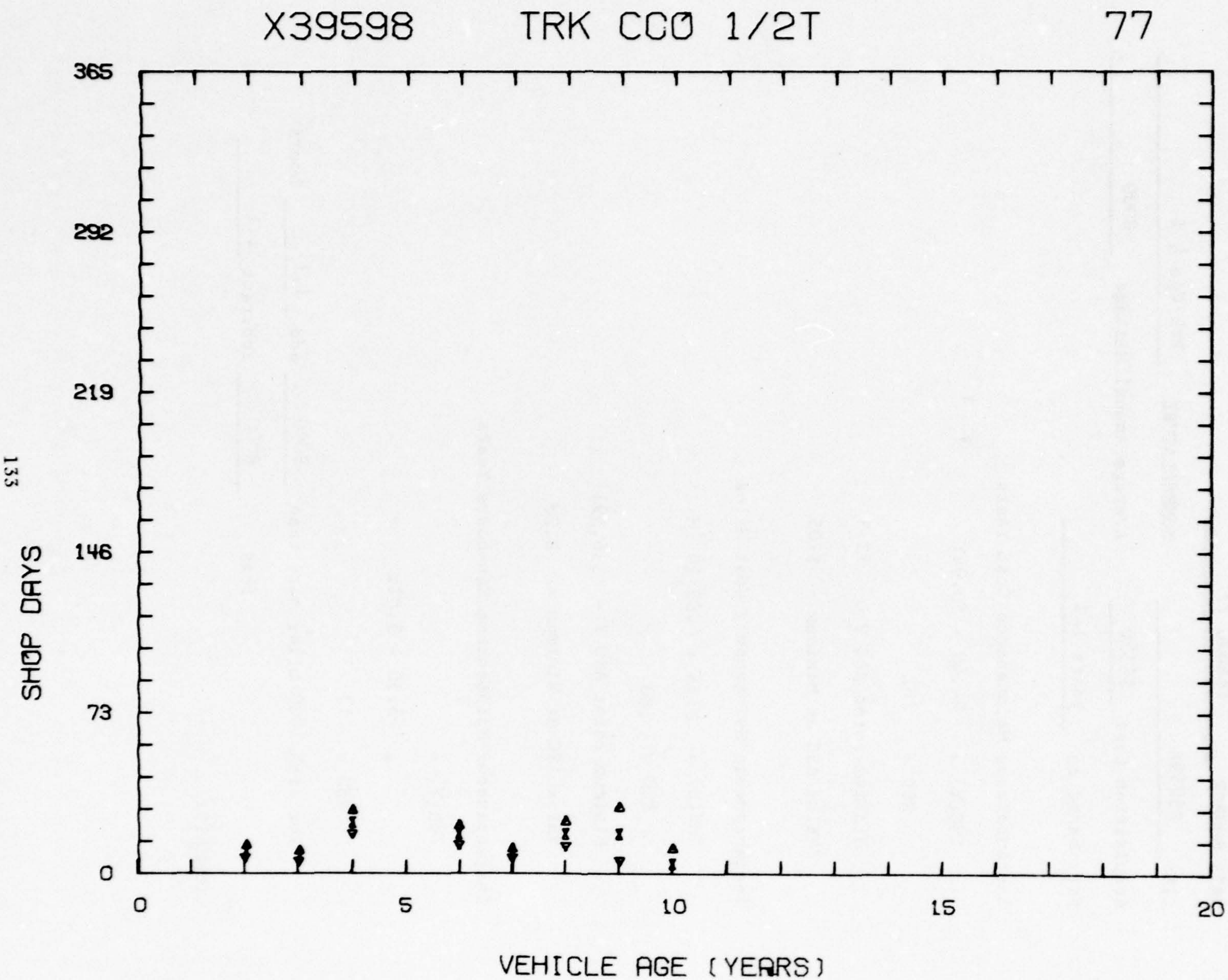

X39598 TRK CCO 1/2T 77
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGO 1/2T 77
COST (DOLLARS X 100)
30
24
18
12
6
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598
TRK CCO 1/2T
77
COST (CENTS)
0
6
12
18
24
30
0
5
10
15
20
MILEAGE (MILES X 10.000)



X39598 TRK CCO 1/2T 77
125
100
75
50
25
0
MANHOURS
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CC0 1/2T 77
365
292
219
146
73
0
SHOP DAYS
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN X39598 NOMENCLATURE Trk Cgo ½ T

Acquisition Cost $4539 Average Annual Mileage 8000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

IMC(Y) = 24.49 + 50.94Y

RSD = 182

Minimum Point ASC Y = 13.3

Value ASC at Minimum = $705

Instantaneous Maintenance Cost Miles

IMC(M) = $.0158 + 4.88 \cdot 10^{-7} M$

RSD = 180

Minimum Point ASC Y = 136,391

Value ASC at Minimum = 8.2¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

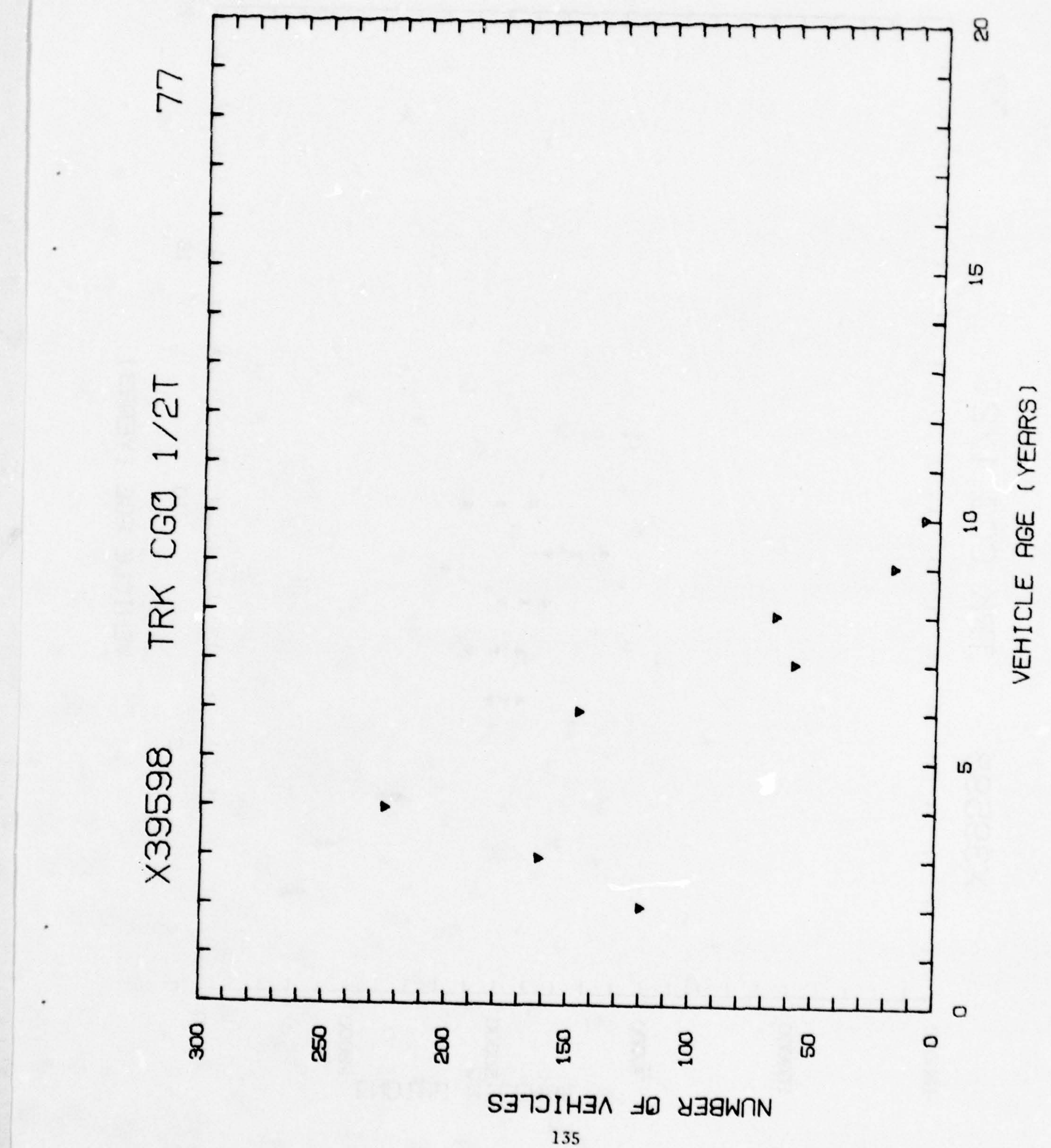
= 3.56 + 3.82Y

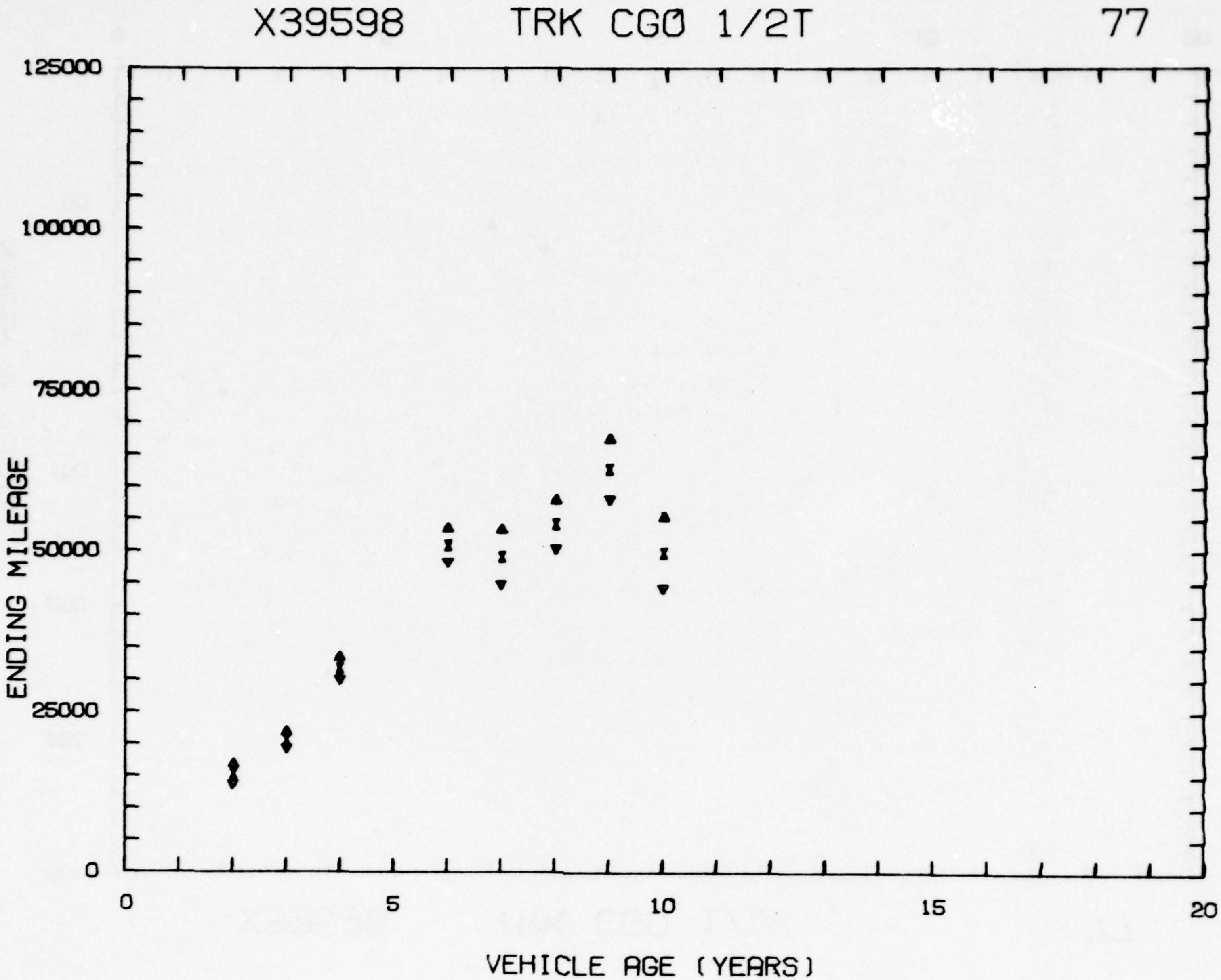
RSD = 13

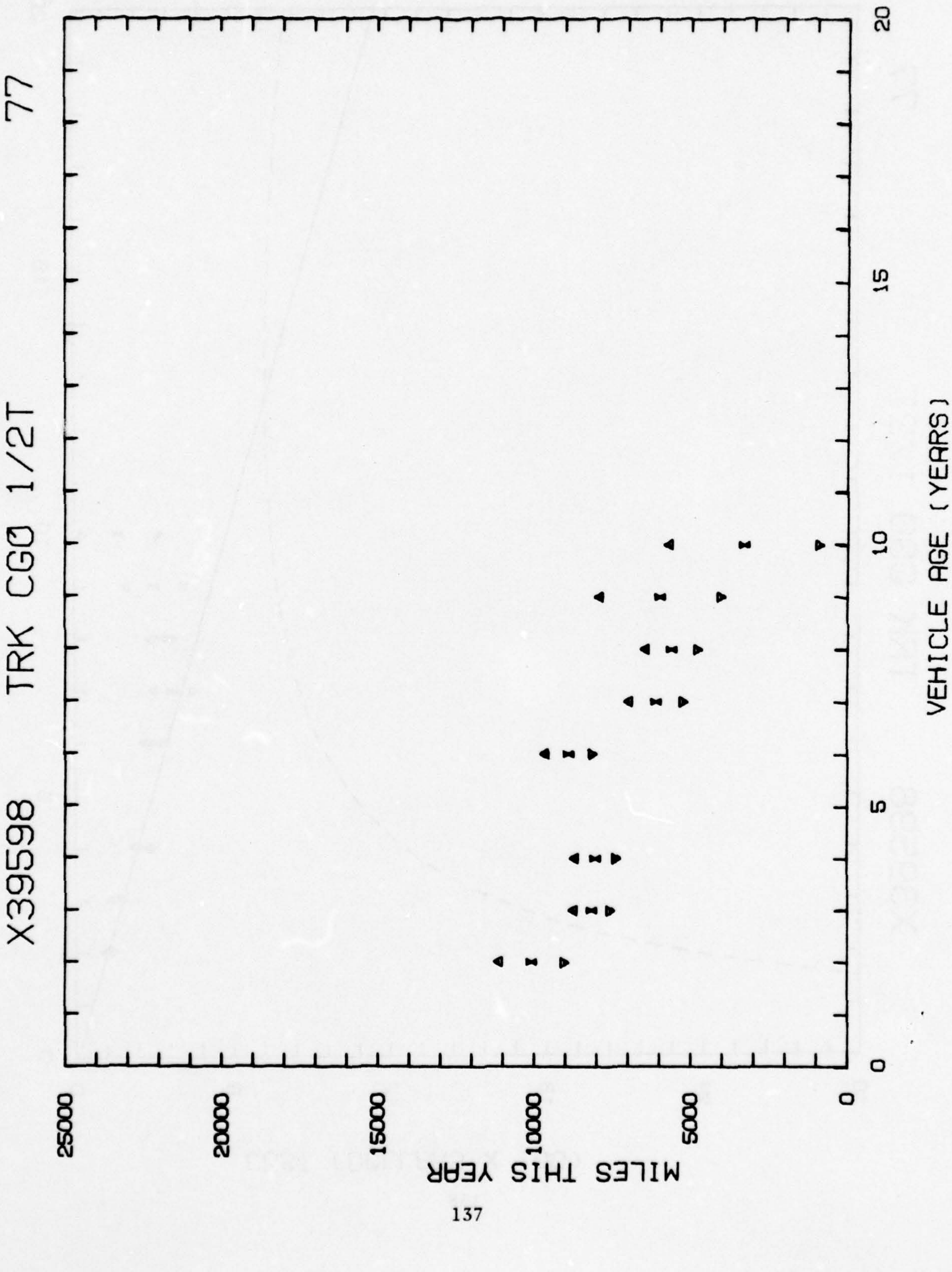
for each 1000 miles more than 8000 add 1.1 hours

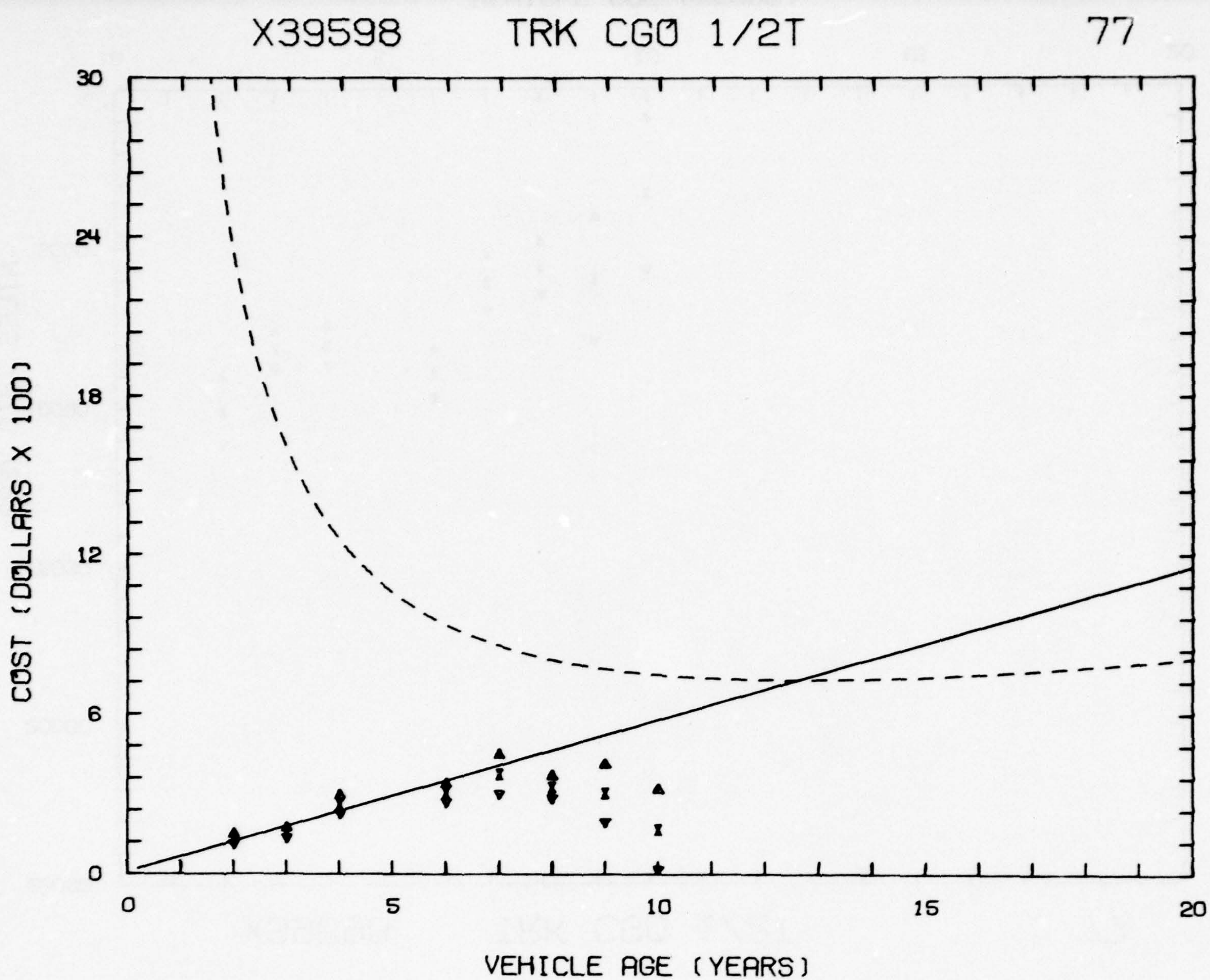
less 8000 subtract 1.1

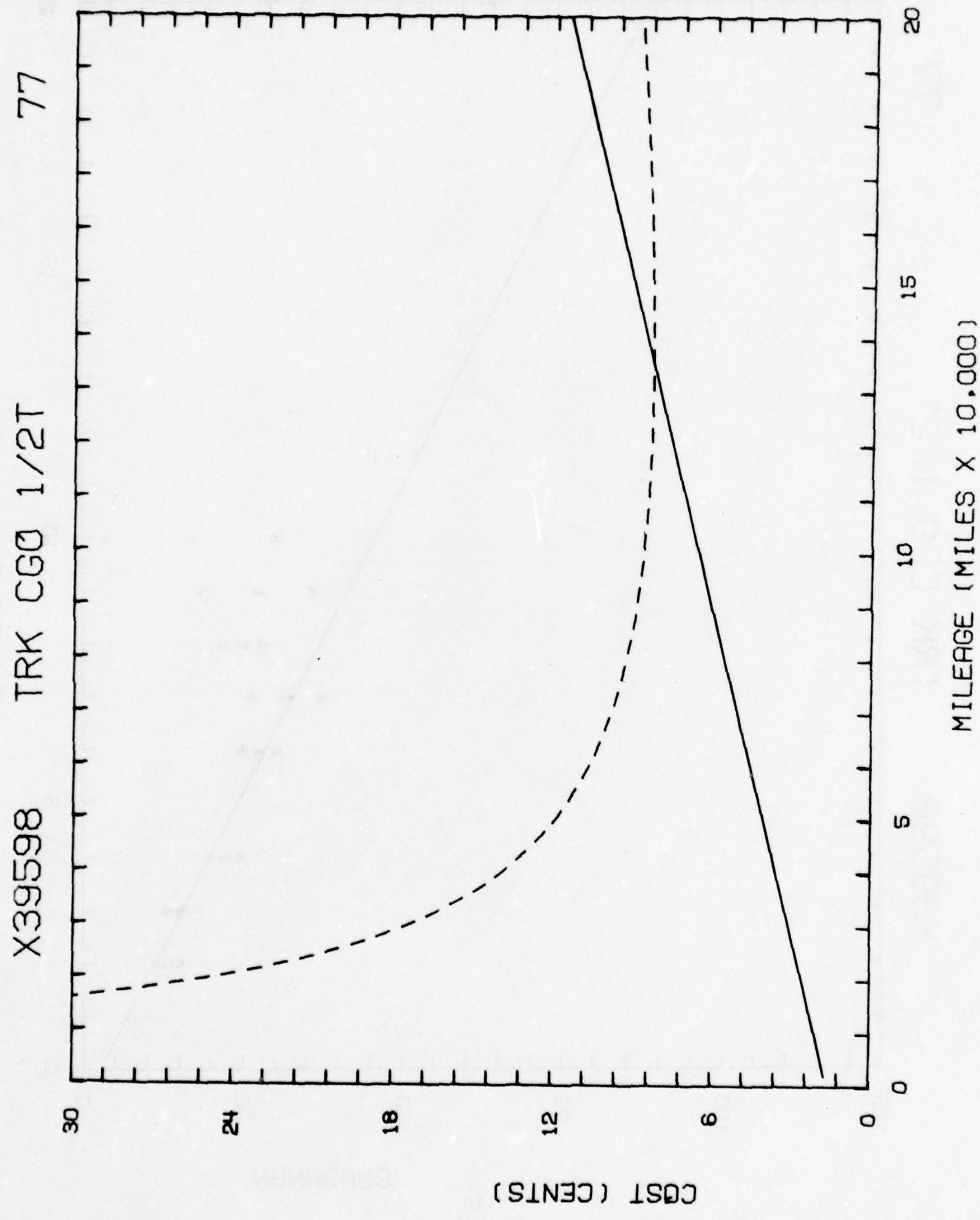
COMMENTS:

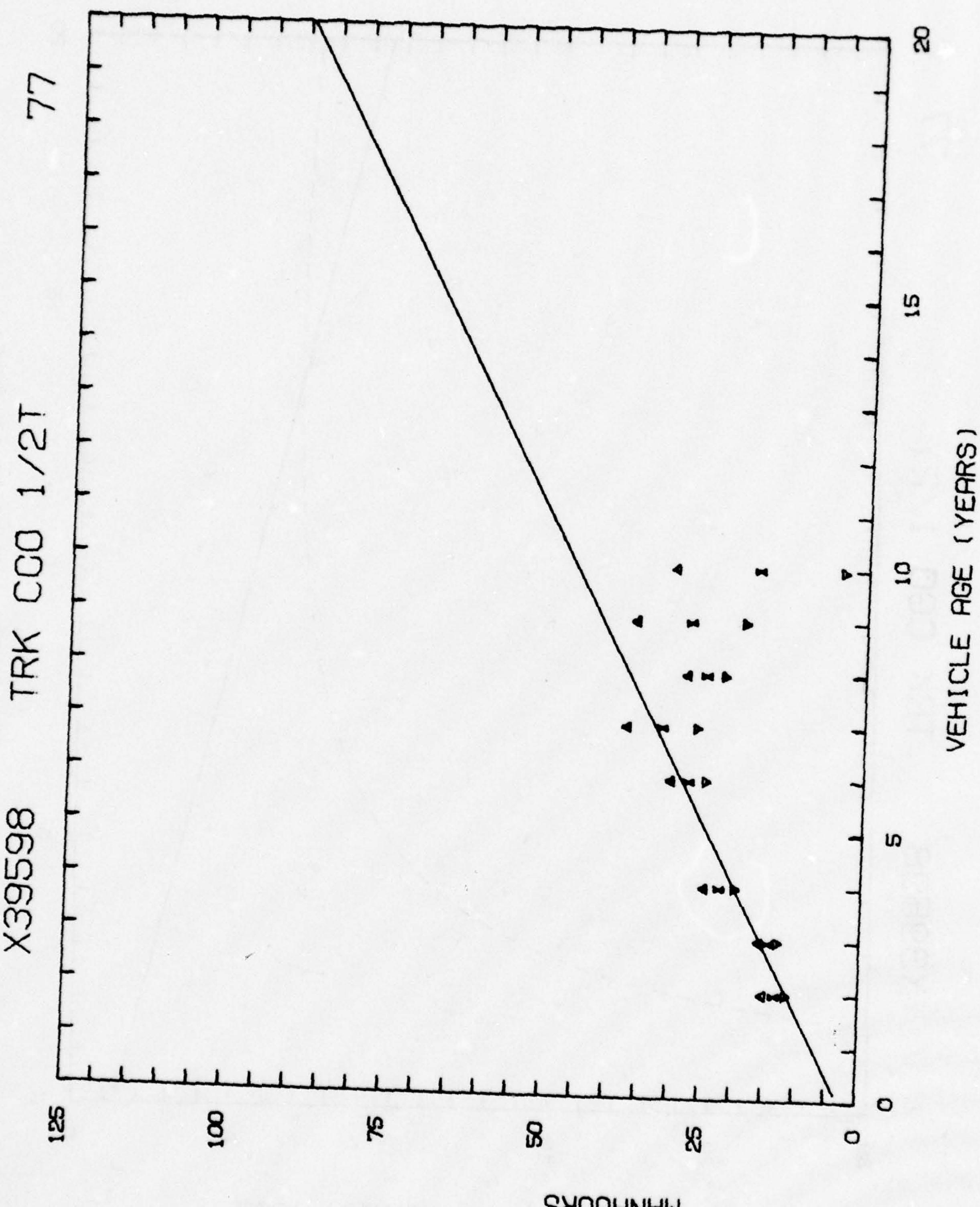

X39598 TRK CGO 1/2T 77
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20

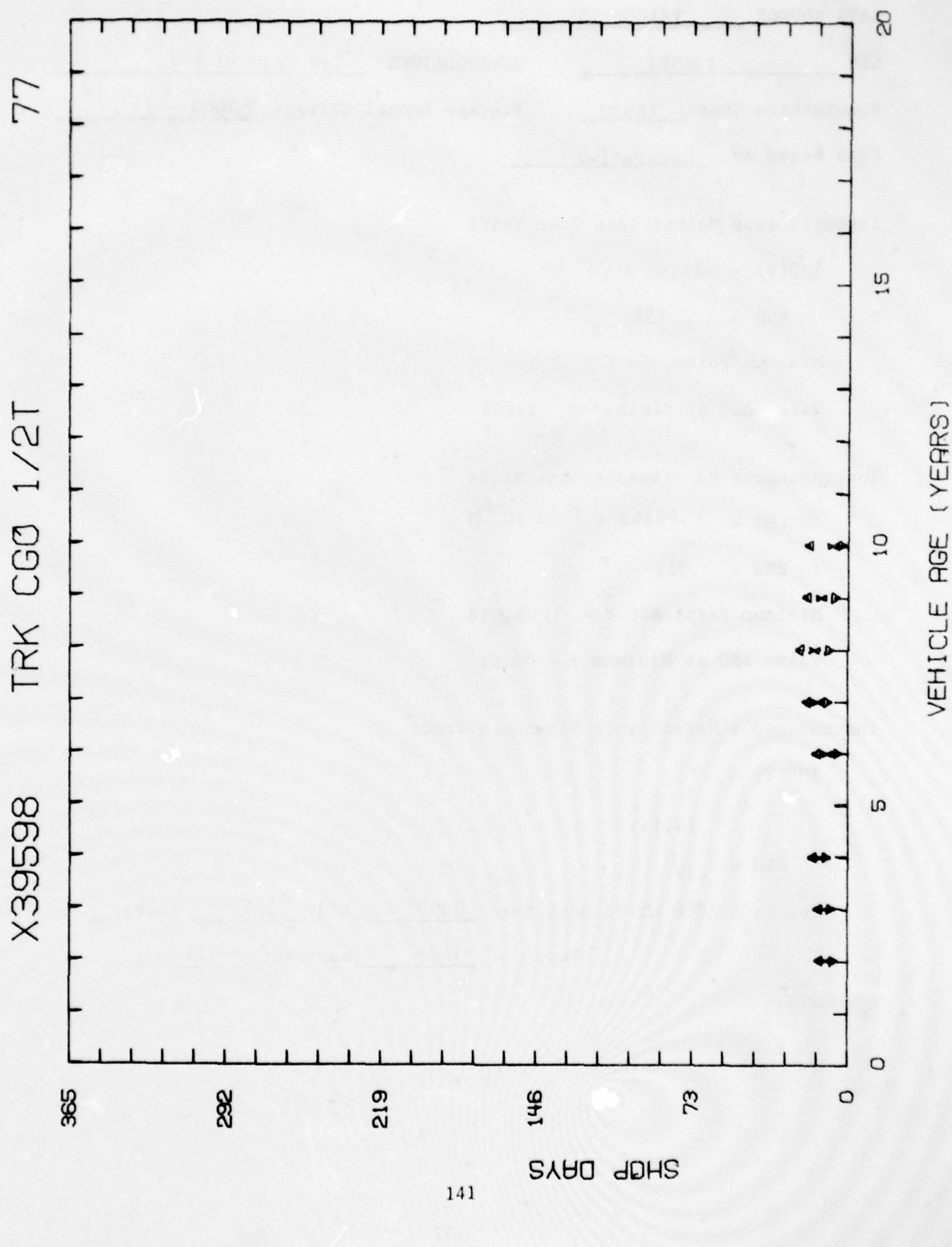

X39598 TRK CGØ 1/2T 77
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGØ 1/2T 77
MILES THIS YEAR
25000
20000
15000
10000
5000
0
VEHICLE AGE (YEARS)
0
5
10
15
20


X39598 TRK CGØ 1/2T 77
COST (DOLLARS X 100)
30
24
18
12
6
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598 TRK CGO 1/2T 77
CØST (CENTS)
0
6
12
18
24
30
0
5
10
15
20
MILEAGE (MILES X 10.000)


X39598 TRK CCO 1/2T 77
MANHOURS
125
100
75
50
25
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X39598
TRK CG0 1/2T
77
SHOP DAYS
0
73
146
219
292
365
VEHICLE AGE (YEARS)
0
5
10
15
20

DATA SOURCE TRADOC 78

LIN X39893 NOMENCLATURE Trk Cgo 1-1 ¼ T

Acquisition Cost $6330 Average Annual Mileage 7000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

IMC(Y) = -74.42 + 237.08

RSD = 752

Minimum Point ASC Y = 7.3

Value ASC at Minimum = $1658

Instantaneous Maintenance Cost Miles

$IMC(M) = .06363 + 2.08 \cdot 10^{-6} M$

RSD = 767

Minimum Point ASC Y = 78,016

Value ASC at Minimum = 22.6¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

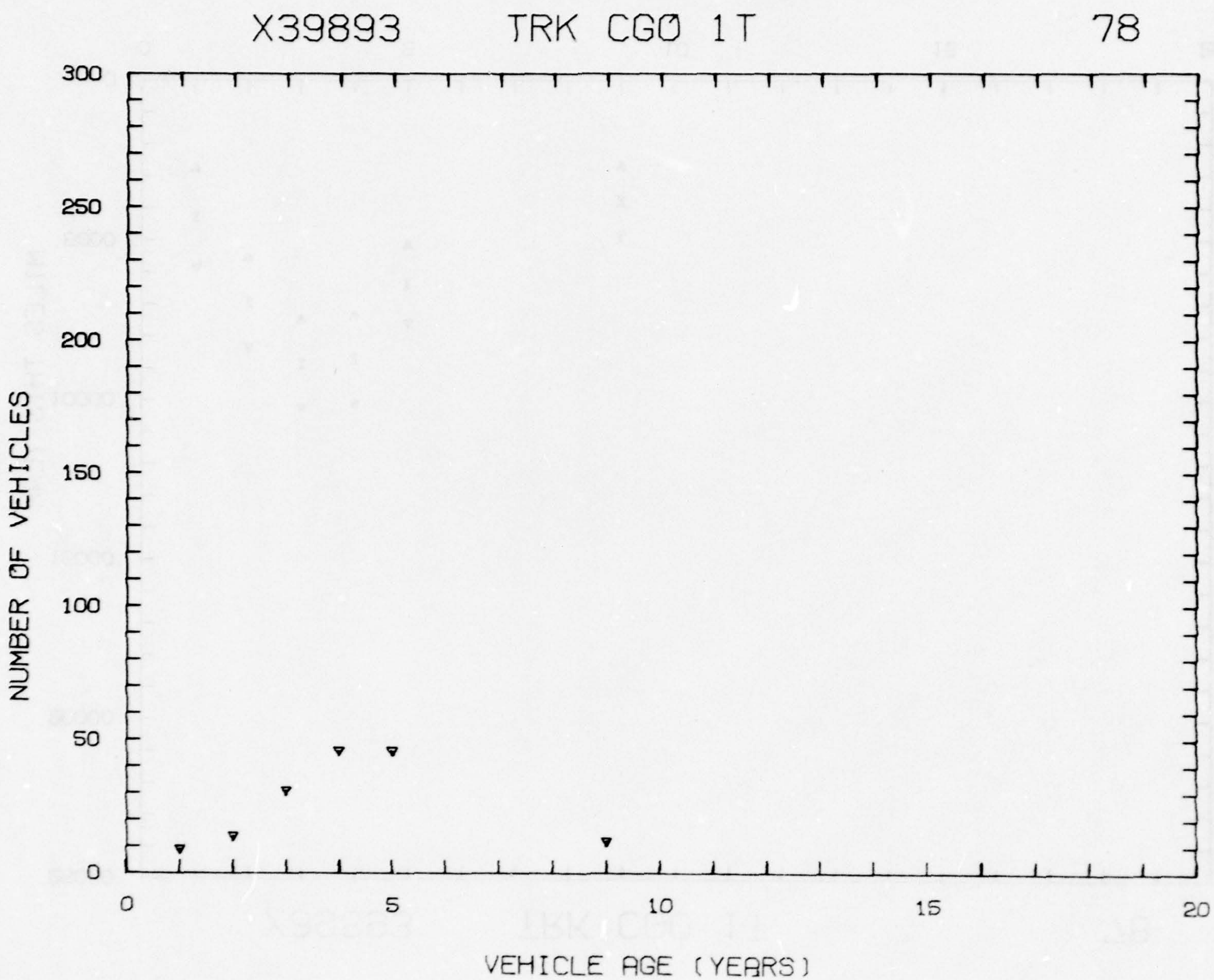
= 14.14Y

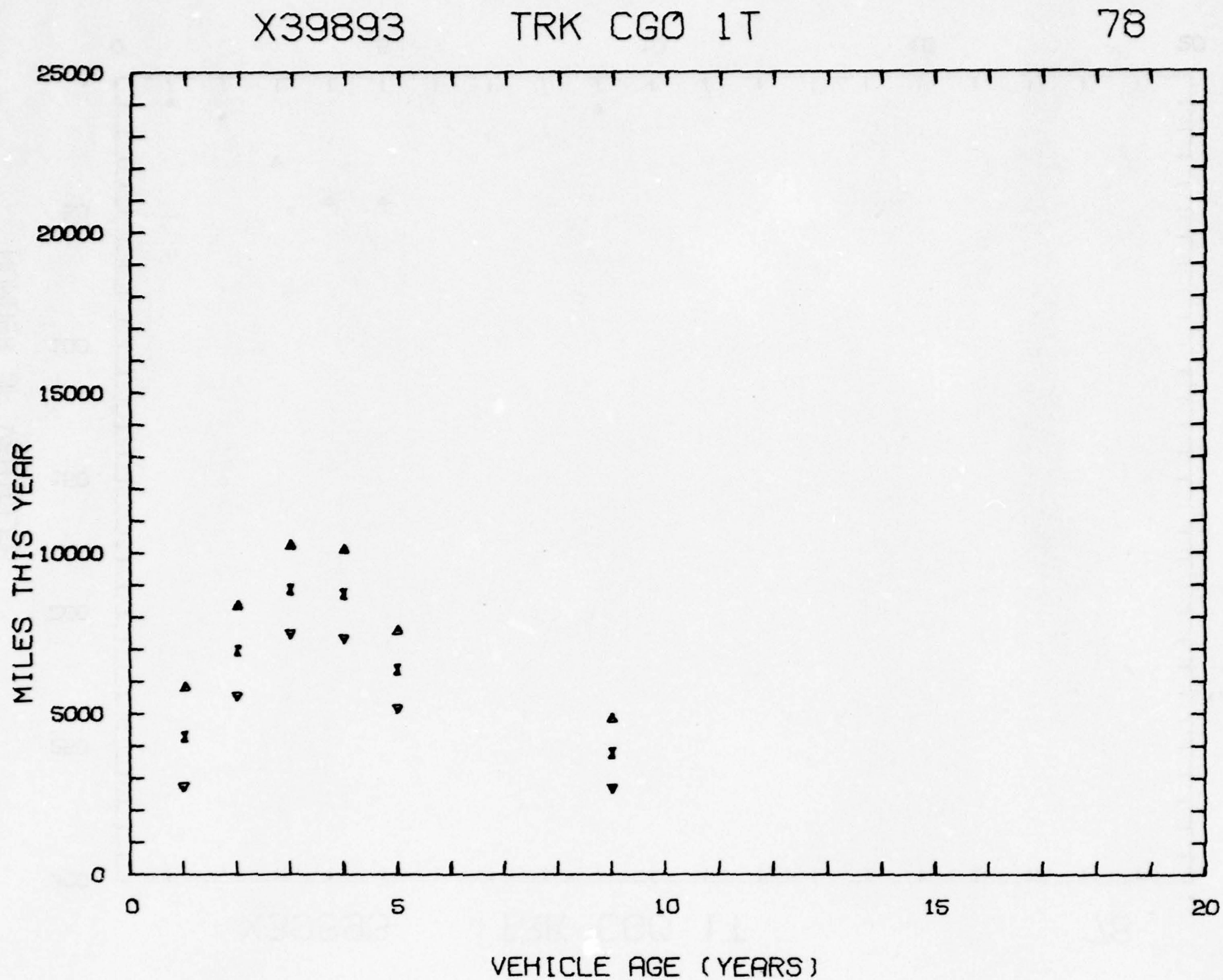
RSD = 39

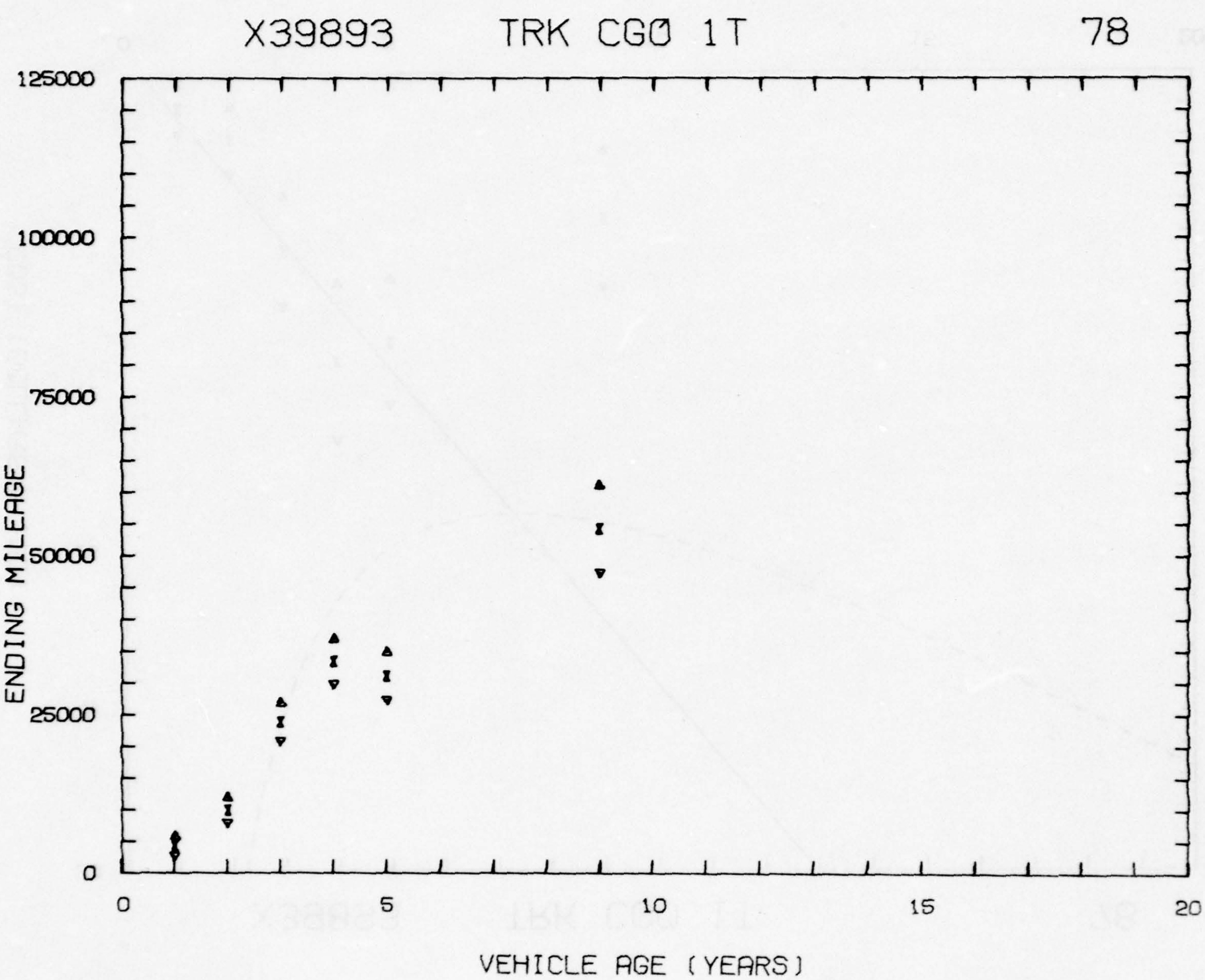
for each 1000 miles more than 7000 add 2.5 hours

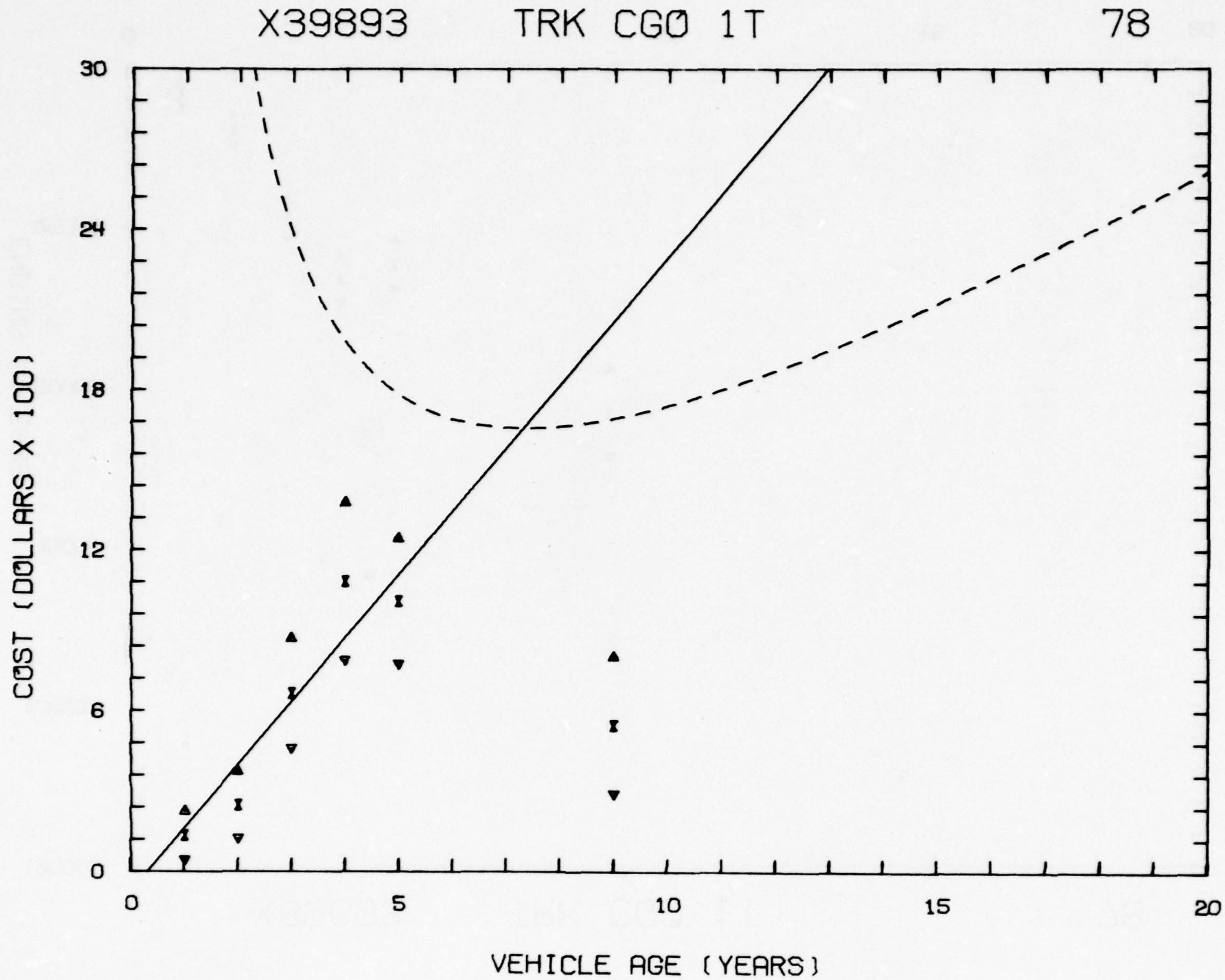
less 7000 subtract 2.5

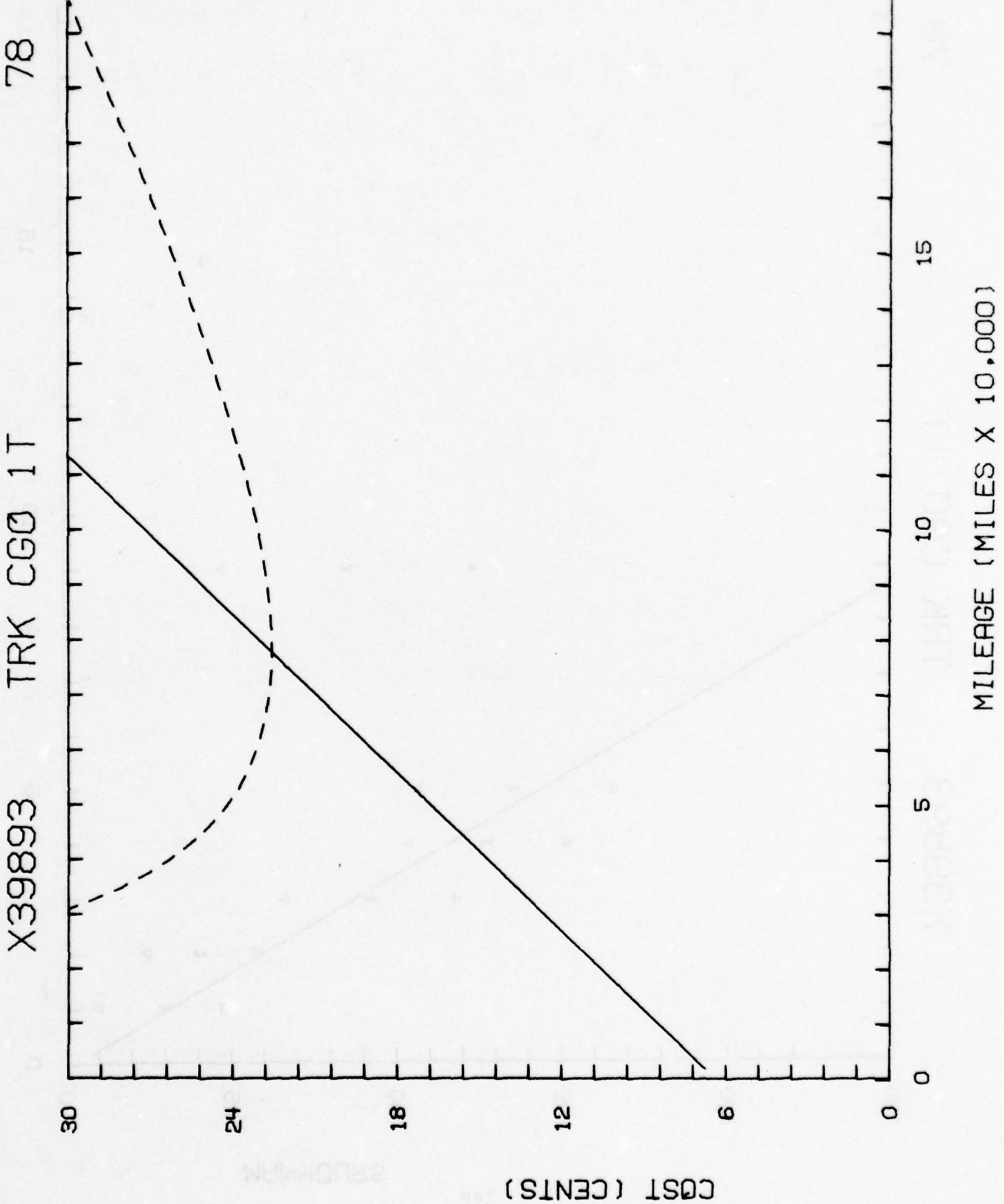
COMMENTS:

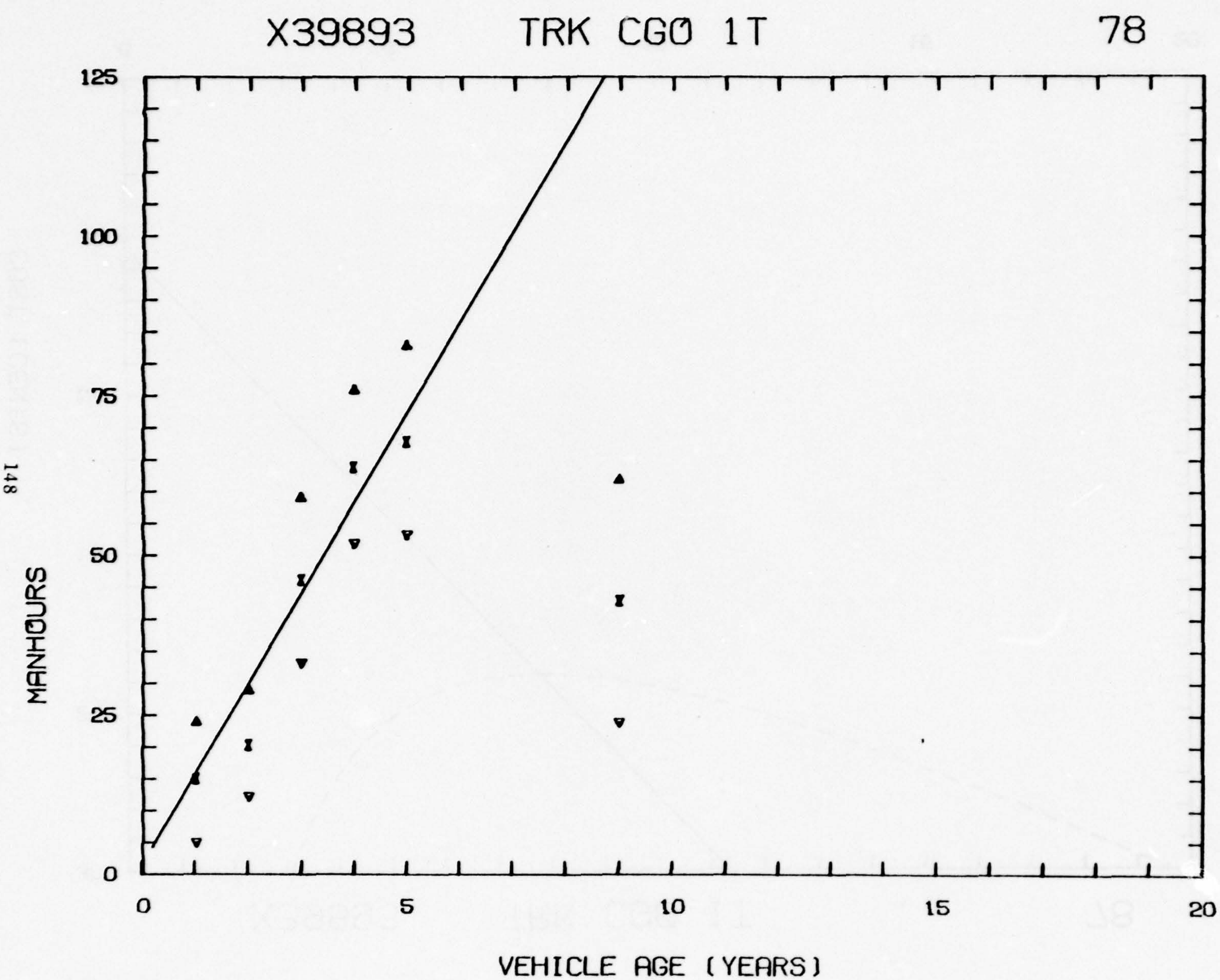

X39893 TRK CGØ 1T 78
NUMBER OF VEHICLES
300
250
200
150
100
50
0
0
5
10
15
20
VEHICLE AGE (YEARS)

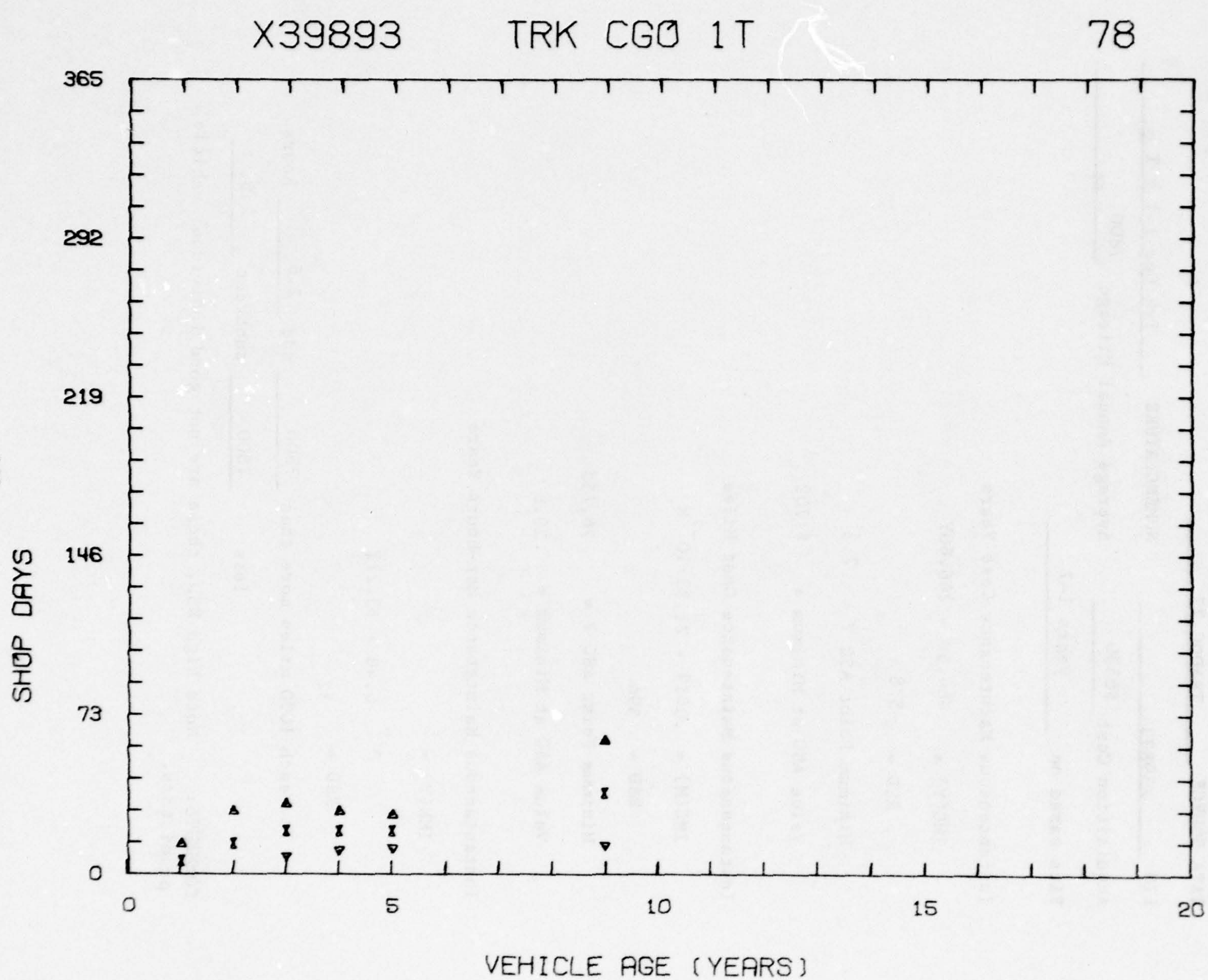

X39893 TRK CGØ 1T 78
MILES THIS YEAR
25000
20000
15000
10000
5000
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X39893
TRK CGØ 1T
78
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)


X39893 TRK CGØ 1T 78
30
24
18
12
6
0
COST (DOLLARS X 100)
0
5
10
15
20
VEHICLE AGE (YEARS)


X39893 TRK CGØ 1T 78
MILEAGE (MILES X 10.000)
CQST (CENTS)
0
5
10
15
20
0
6
12
18
24
30


X39893 TRK CGØ 1T 78
MANHOURS
125
100
75
50
25
0
5
10
15
20
VEHICLE AGE (YEARS)


X39893 TRK CGØ 1T 78
365
292
219
146
73
0
SHØP DAYS
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN X39893 NOMENCLATURE Trk Cgo 1-1 ¼ T

Acquisition Cost $6330 Average Annual Mileage 7800

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$$IMC(Y) = -64.50 + 246.60Y$$

RSD = 578

Minimum Point ASC Y = 7.2

Value ASC at Minimum = $1702

Instantaneous Maintenance Cost Miles

$$IMC(M) = .0419 + 21.83 \cdot 10^{-7} M$$

RSD = 594

Minimum Point ASC Y = 76,153

Value ASC at Minimum = 20.8

Instantaneous Maintenance Man-hours Years

IMH(Y) =

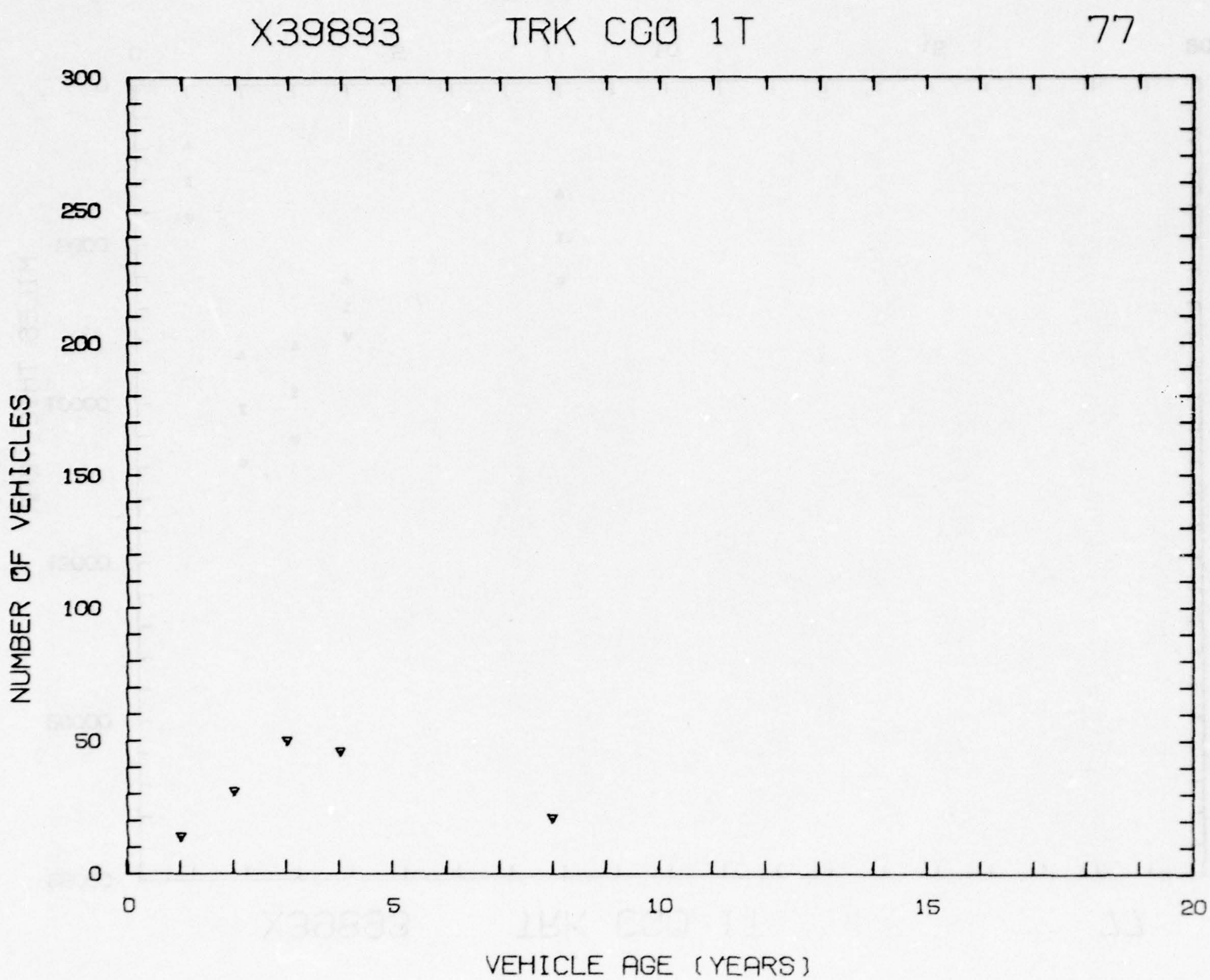
$$= 6.48 + 13.21Y$$

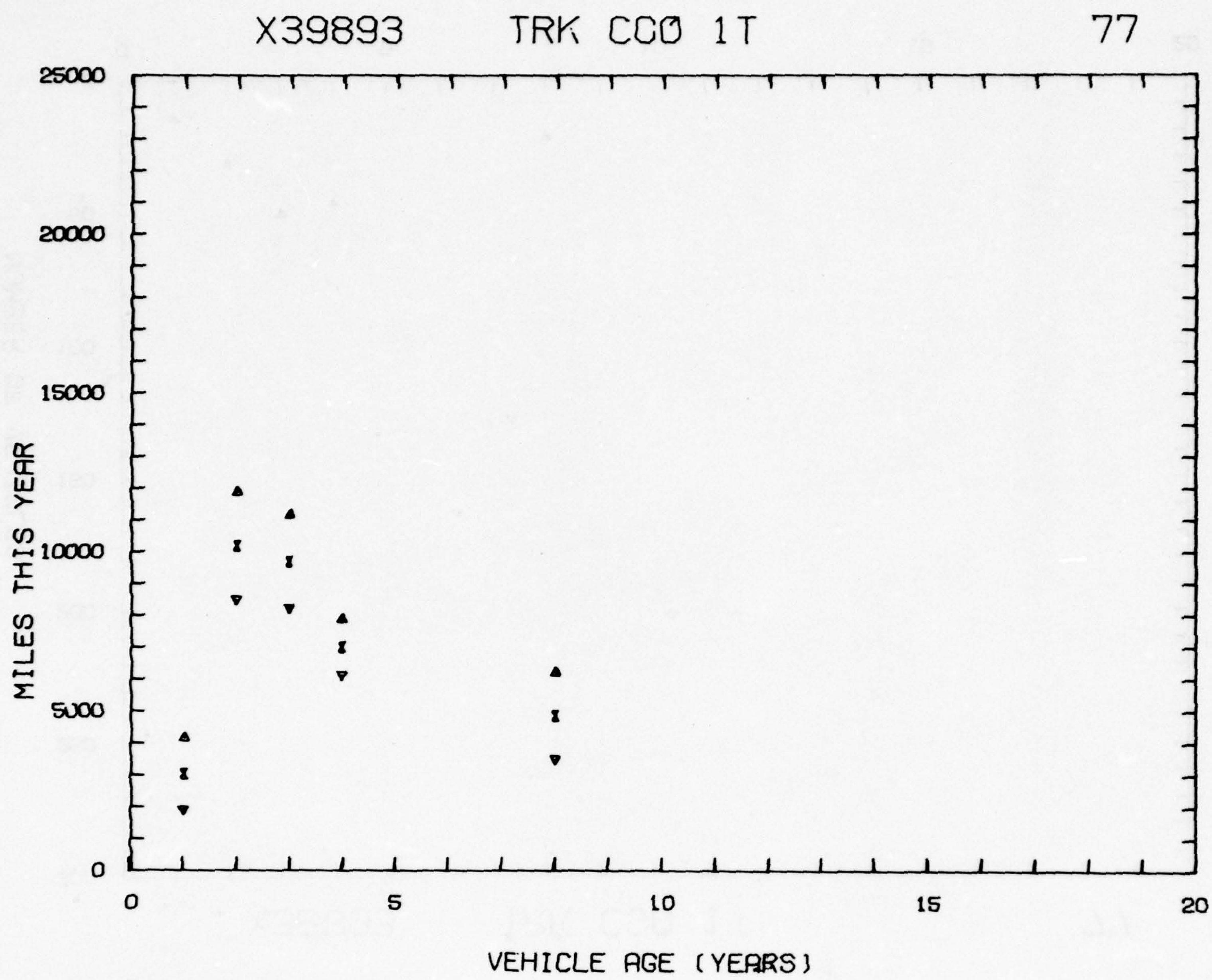
RSD = 32

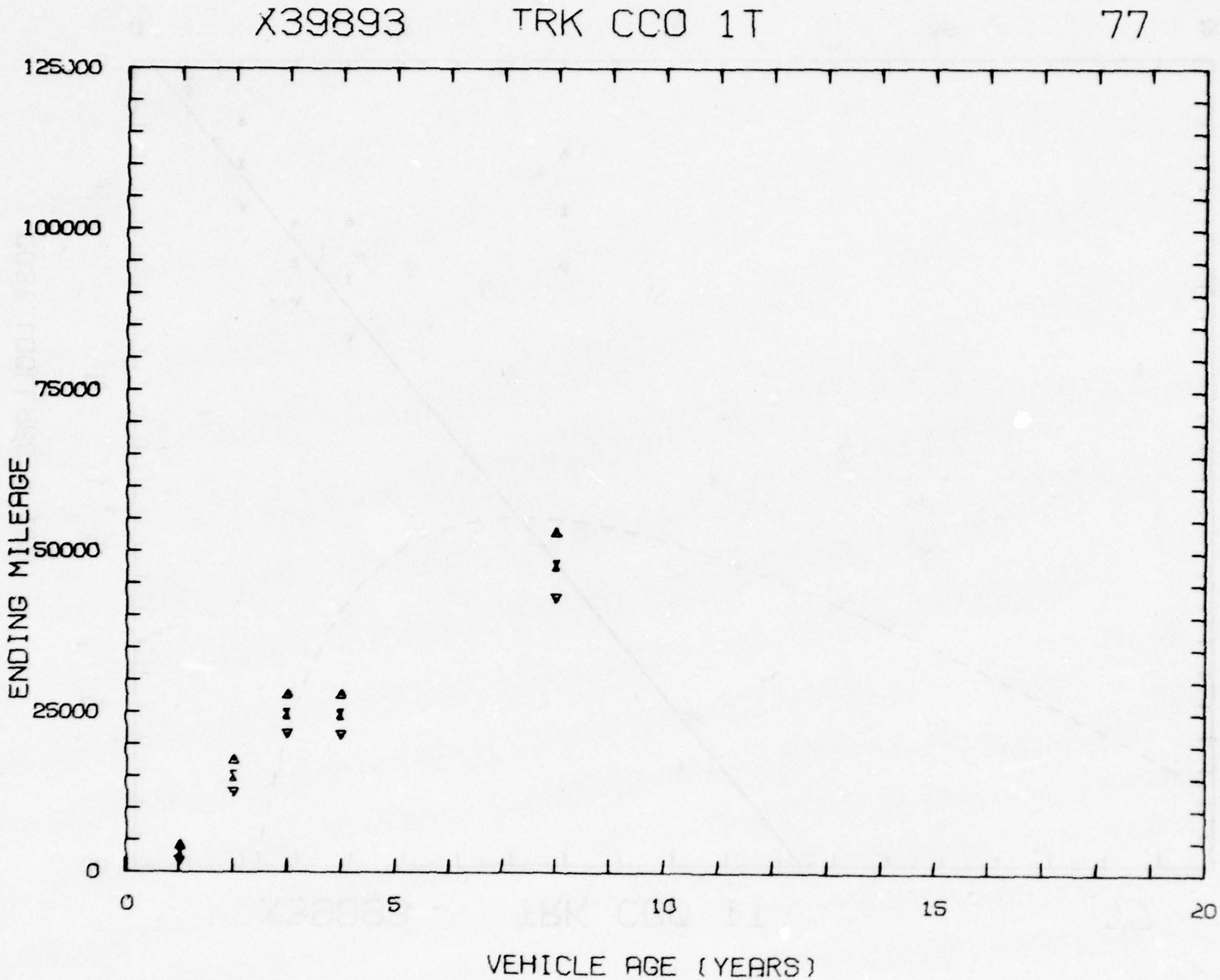
for each 1000 miles more than 7800 add 2.6 hours

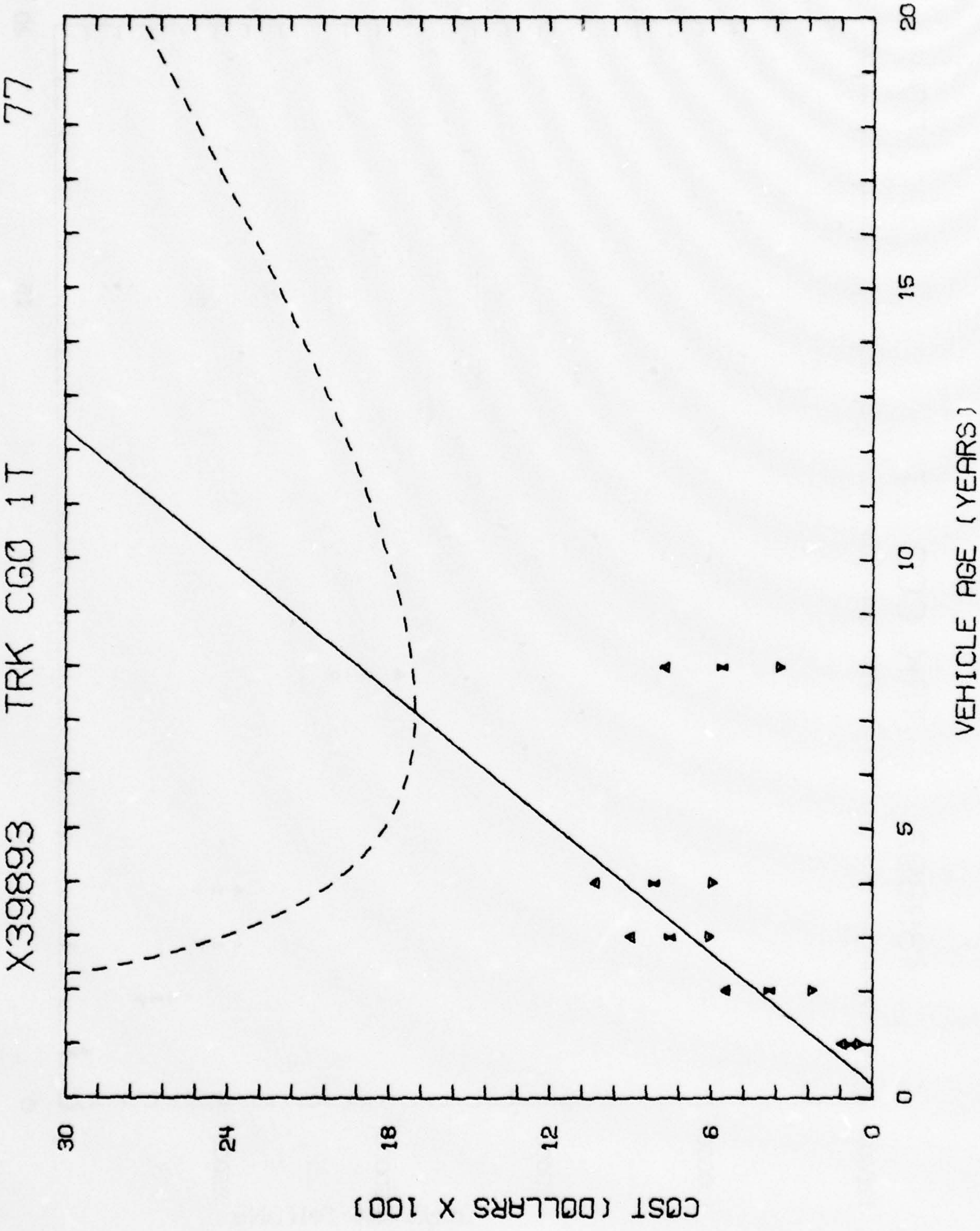
less 7800 subtract 2.6

COMMENTS: Note high RSD, these are not good individual vehicle predictors.

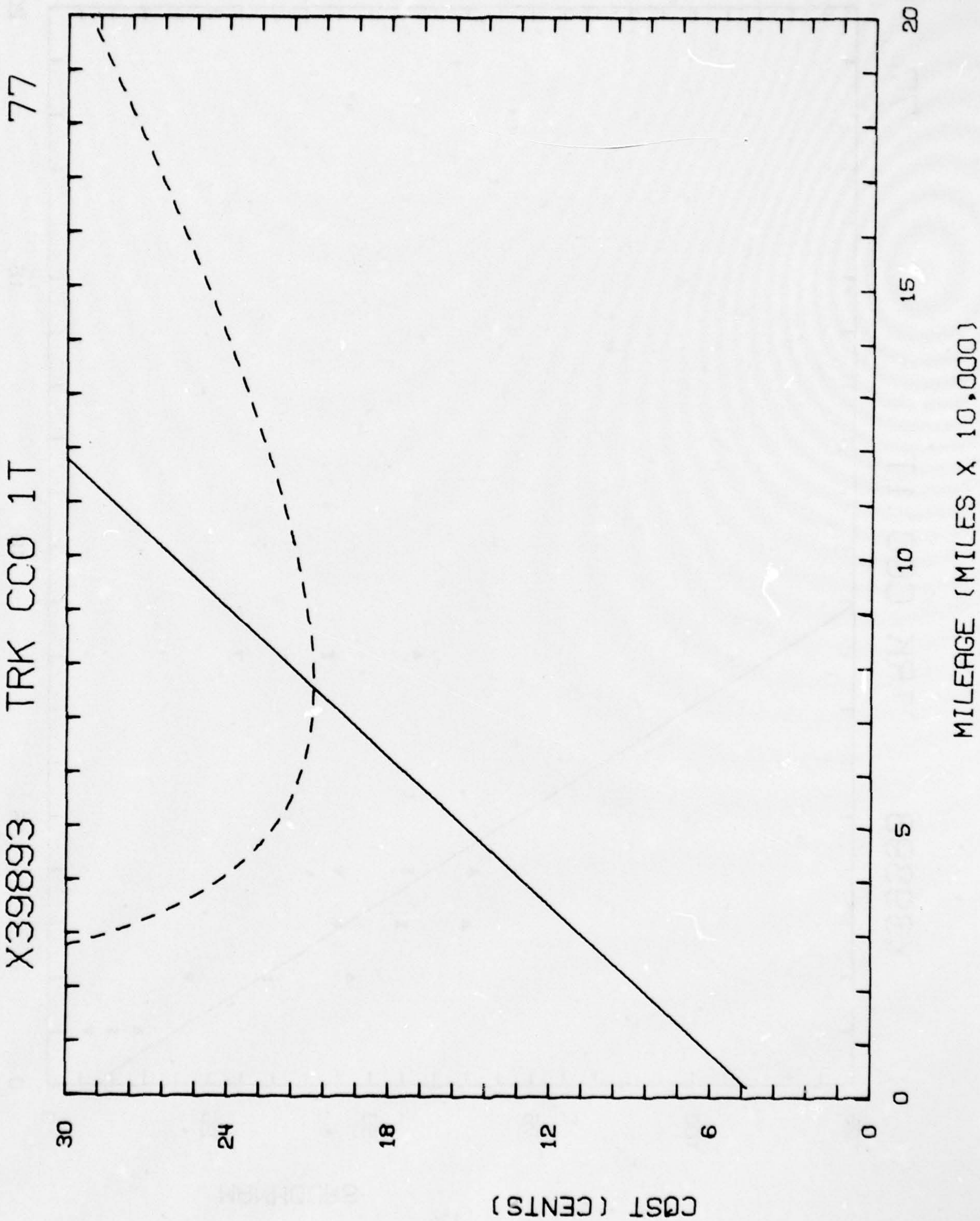

X39893 TRK CGØ 1T 77
NUMBER OF VEHICLES
300
250
200
150
100
50
0
0
5
10
15
20
VEHICLE AGE (YEARS)

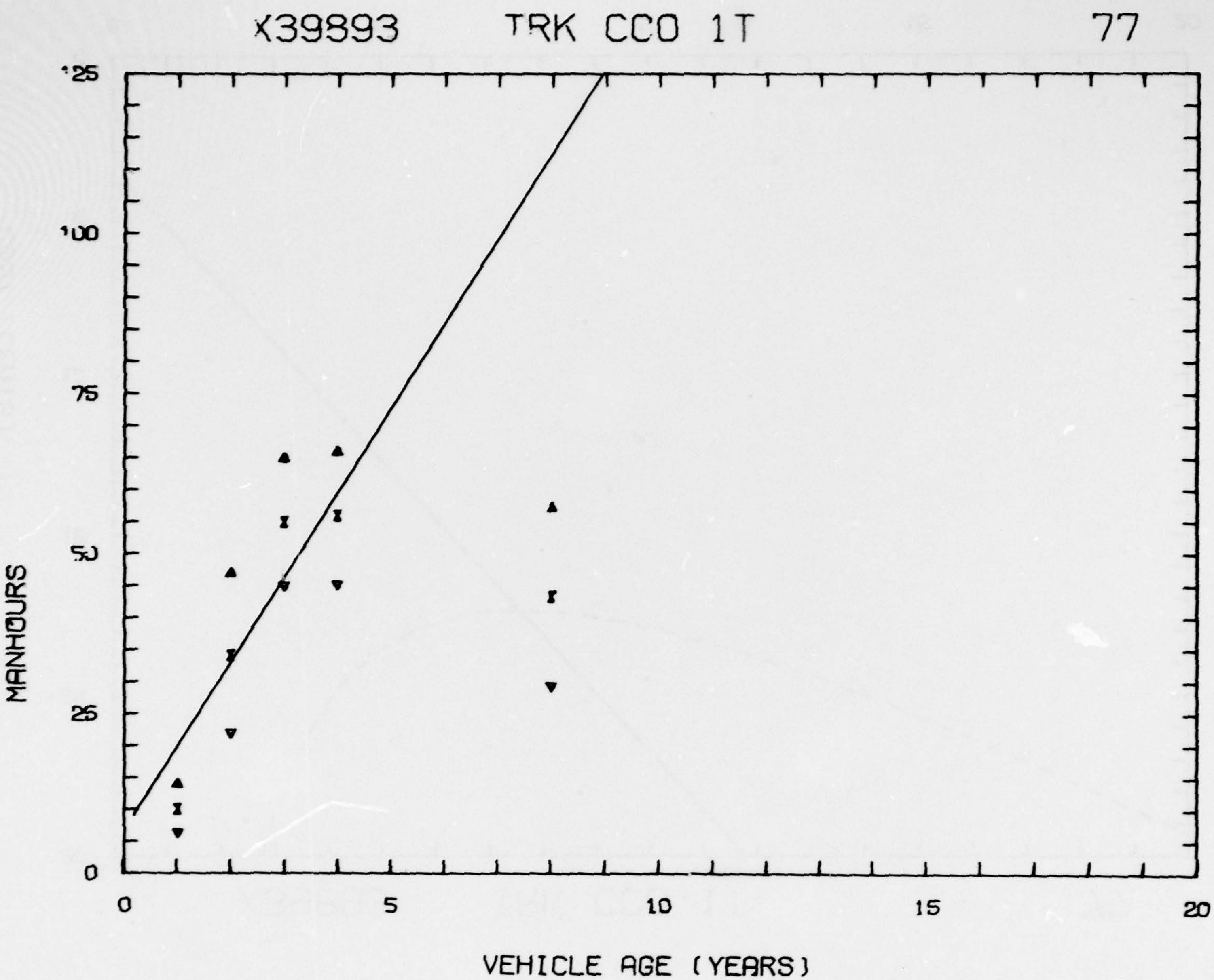

X39893 TRK CC0 1T 77
MILES THIS YEAR
25000
20000
15000
10000
5000
0
0
5
10
15
20
VEHICLE AGE (YEARS)

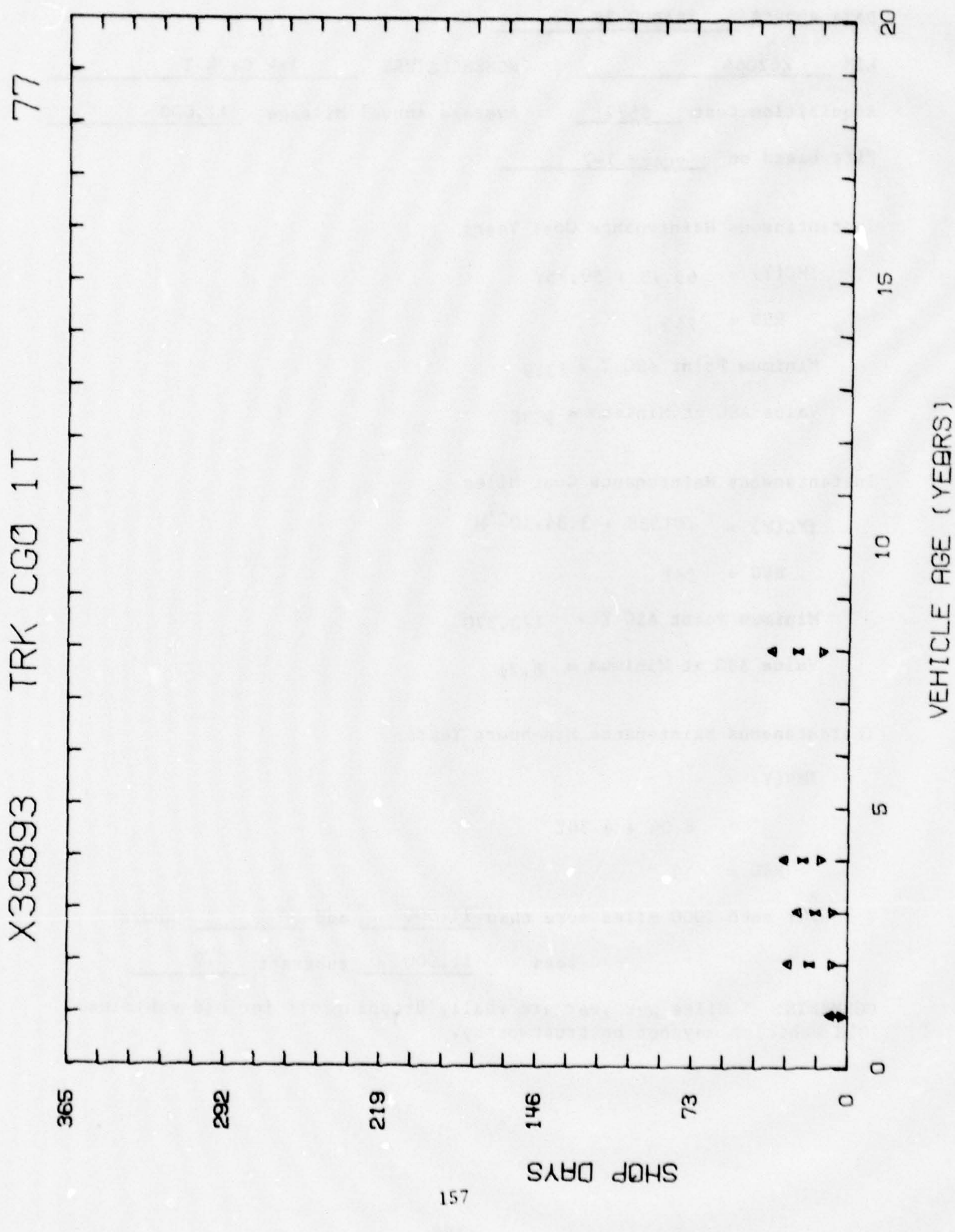

X39893 TRK CCO 1T 77
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)



X39893 TRK CGO 1T 77
COST (DOLLARS X 100)
0
6
12
18
24
30
VEHICLE AGE (YEARS)
0
5
10
15
20


X39893 TRK CCO 1T 77
COST (CENTS)
30
24
18
12
6
0
0
5
10
15
20
MILEAGE (MILES X 10,000)


X39893 TRK CCO 1T 77
MANHOURS
0
25
50
75
100
125
0
5
10
15
20
VEHICLE AGE (YEARS)


X39893 TRK CGO 1T 77
SHOP DAYS
365
292
219
146
73
0
VEHICLE AGE (YEARS)
0
5
10
15
20

DATA SOURCE TRADOC 78

LIN X42064 NOMENCLATURE Trk Ca ½ T

Acquisition Cost $5771 Average Annual Mileage 11,000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 65.73 + 59.75Y$

RSD = 265

Minimum Point ASC Y = 13.9

Value ASC at Minimum = $896

Instantaneous Maintenance Cost Miles

$IMC(M) = .01538 + 3.84 \cdot 10^{-7} M$

RSD = 261

Minimum Point ASC Y = 173,370

Value ASC at Minimum = 8.2¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

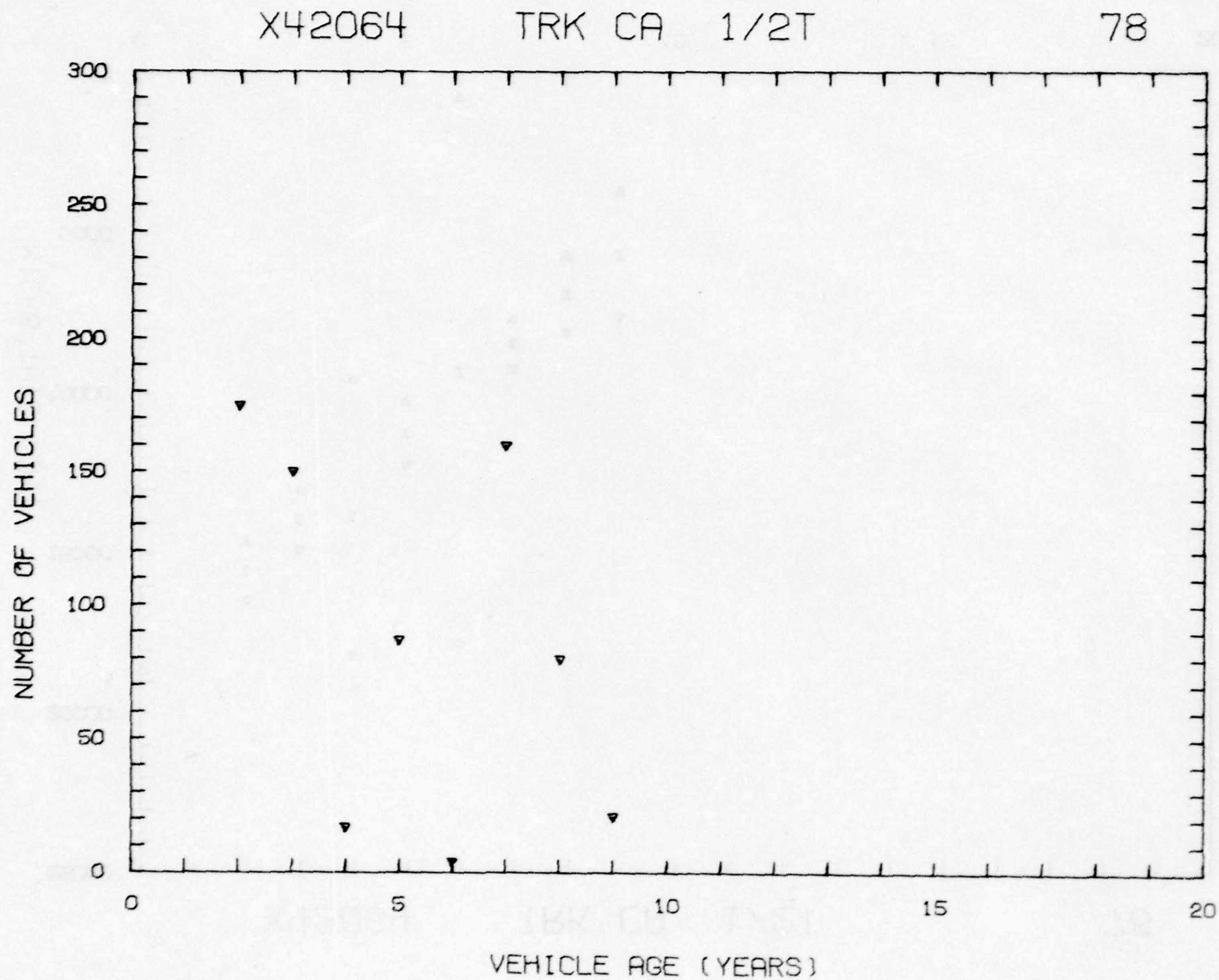
$= 6.04 + 4.38Y$

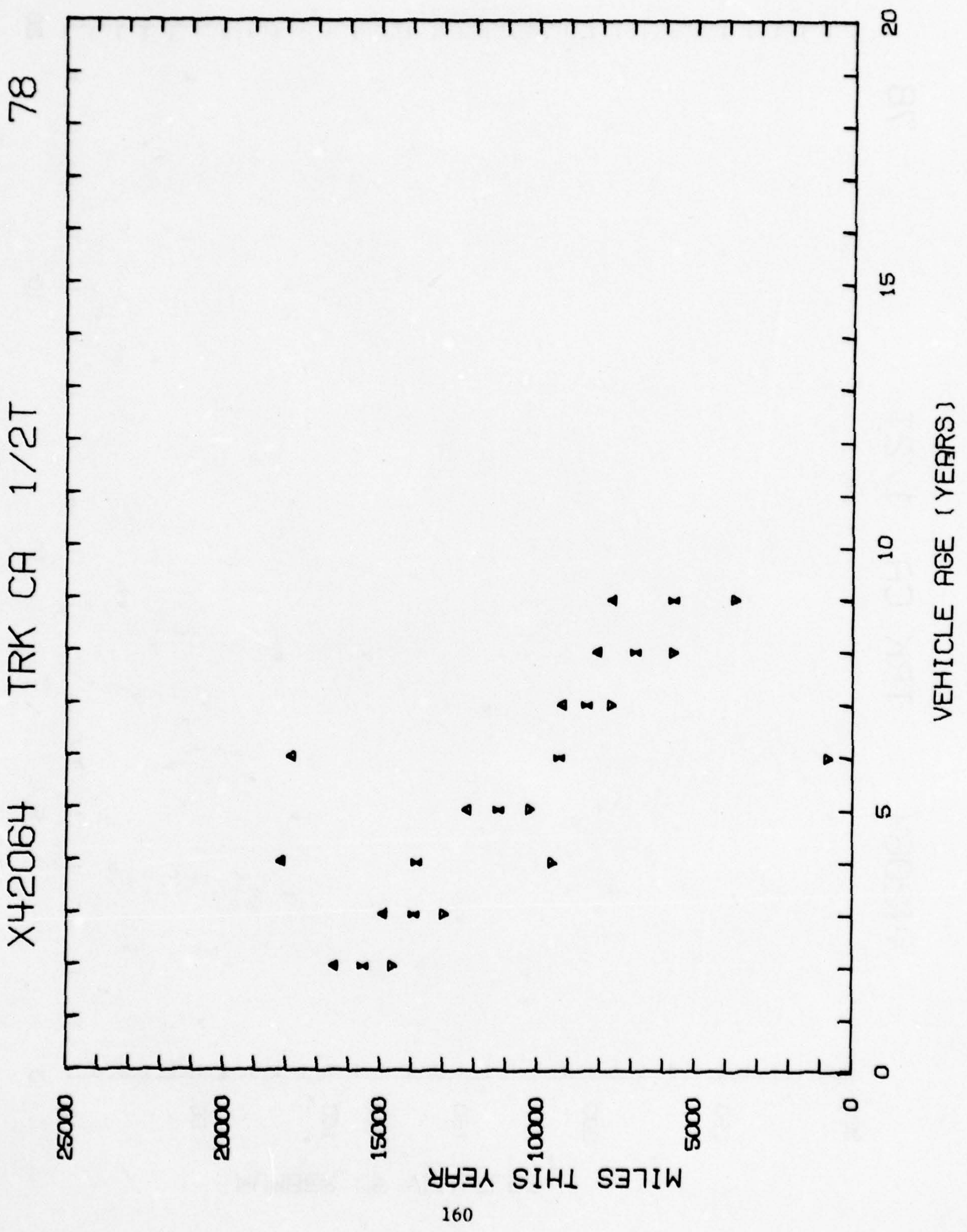
RSD = 19

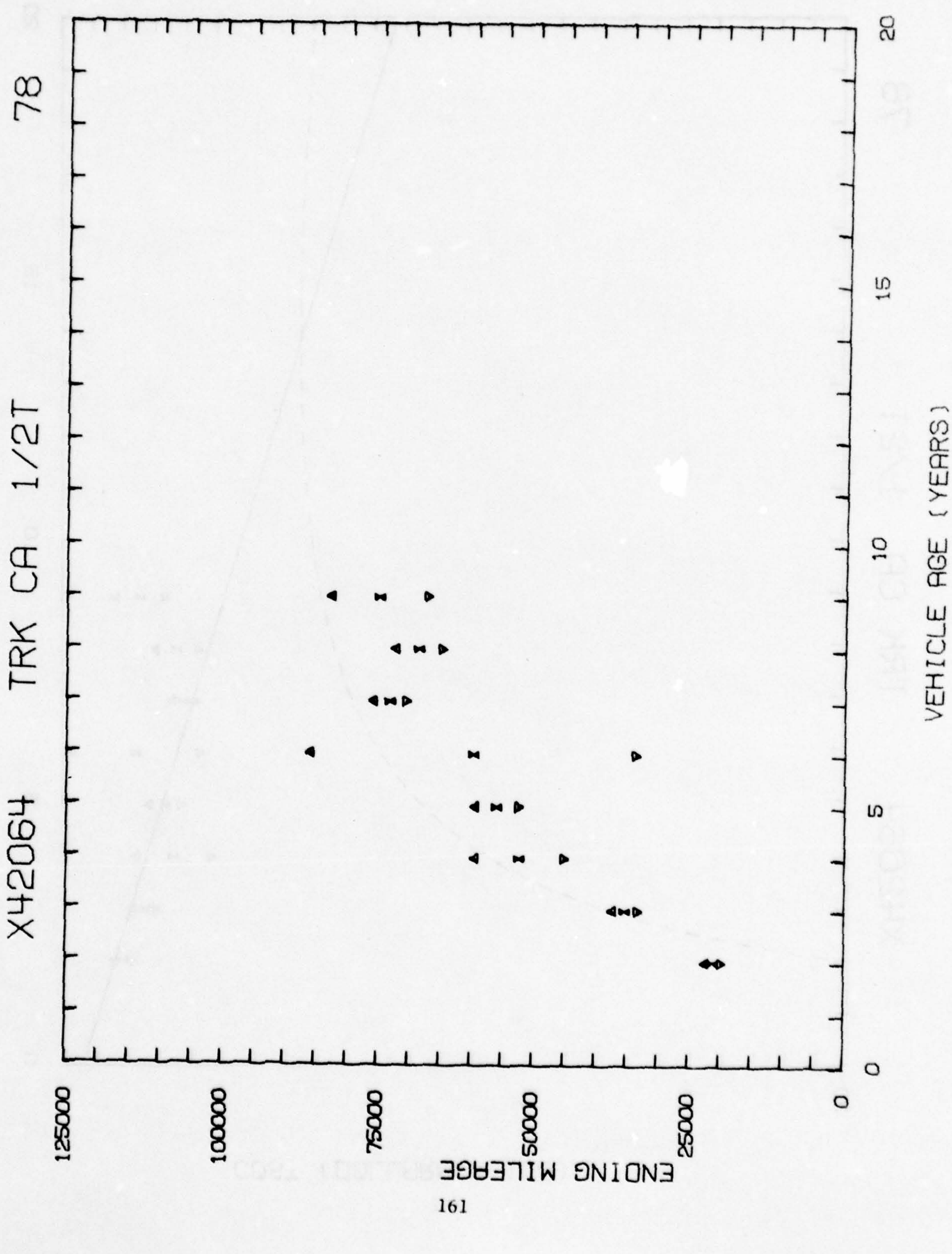
for each 1000 miles more than 11,000 add .9 hours

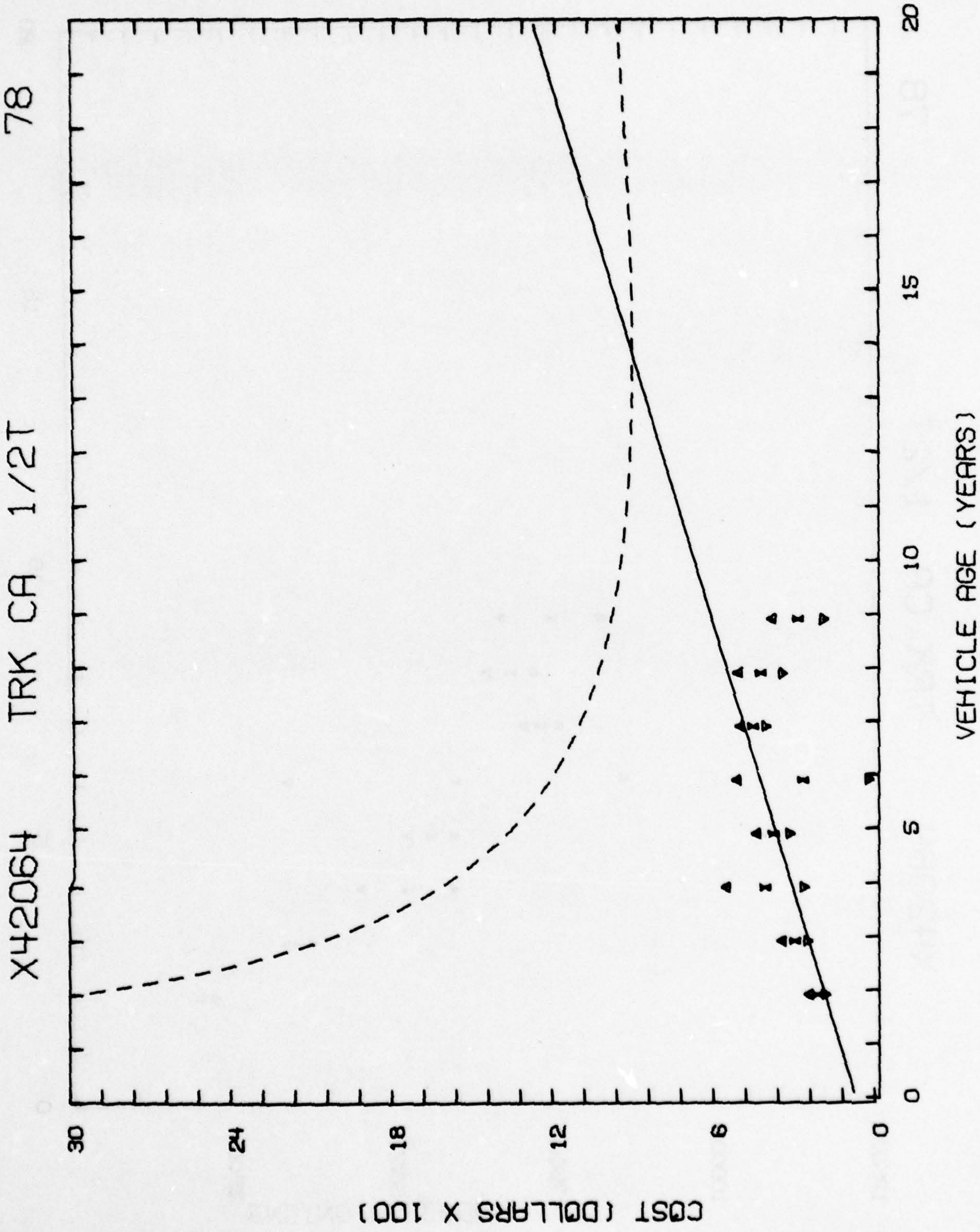
less 11,000 subtract .9

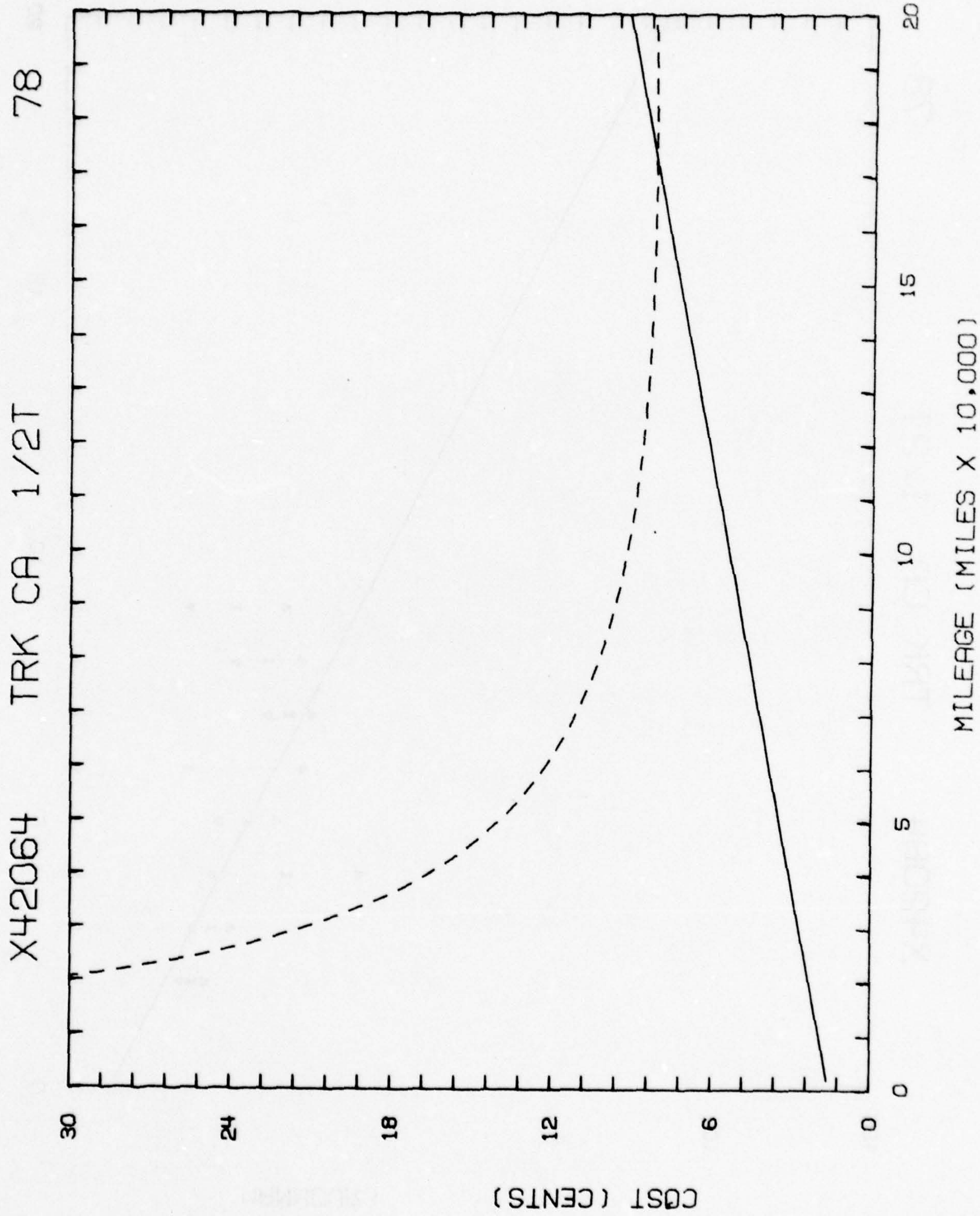
COMMENTS: Miles per year are really dropping off for old vehicles. Old vehicles may not be trustworthy.


X42064 TRK CA 1/2T 78
NUMBER OF VEHICLES
300
250
200
150
100
50
0
0
5
10
15
20
VEHICLE AGE (YEARS)

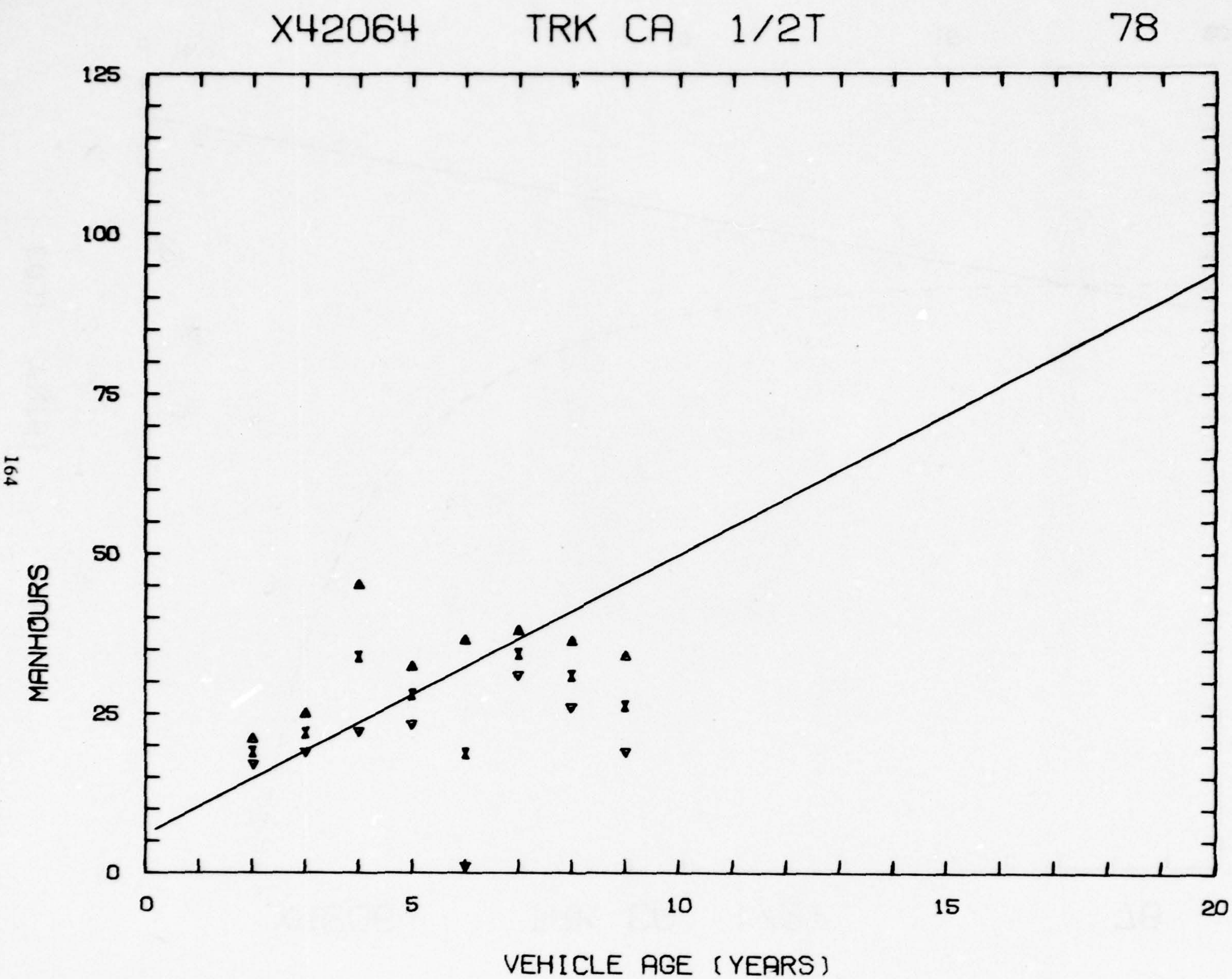

X42064 TRK CA 1/2T 78
MILES THIS YEAR
25000
20000
15000
10000
5000
0
VEHICLE AGE (YEARS)
0
5
10
15
20

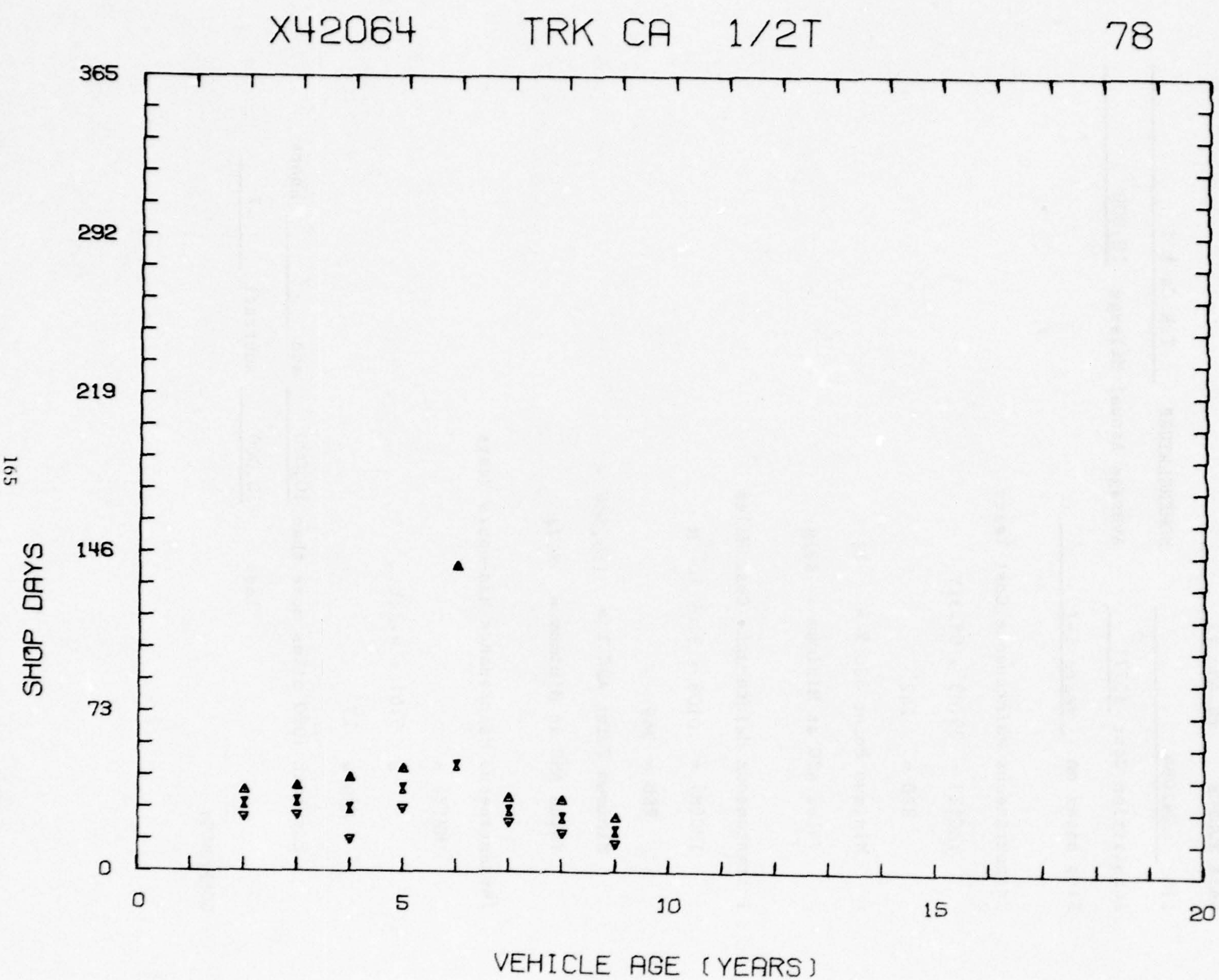

X42064 TRK CA 1/2T 78
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)


X42064 TRK CA 1/2T 78
COST (DOLLARS X 100)
30
24
18
12
6
0
0
5
10
15
20
VEHICLE AGE (YEARS)



X42064 TRK CA 1/2T 78
COST (CENTS)
0
6
12
18
24
30
MILEAGE (MILES X 10,000)
0
5
10
15
20


X42064 TRK CA 1/2T 78
MANHOURS
0
25
50
75
100
125
0
5
10
15
20
VEHICLE AGE (YEARS)


X42064 TRK CA 1/2T 78
365
292
219
146
73
0
SHOP DAYS
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN X42064 NOMENCLATURE Trk Ca ½ T

Acquisition Cost $5771 Average Annual Mileage 10,000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 29.83 + 68.31Y$

RSD = 242

Minimum Point ASC Y = 13

Value ASC at Minimum = $918

Instantaneous Maintenance Cost Miles

$IMC(M) = .0108 + 5.09 \cdot 10^{-7} M$

RSD = 249

Minimum Point ASC Y = 150,584

Value ASC at Minimum = 8.7¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) =$

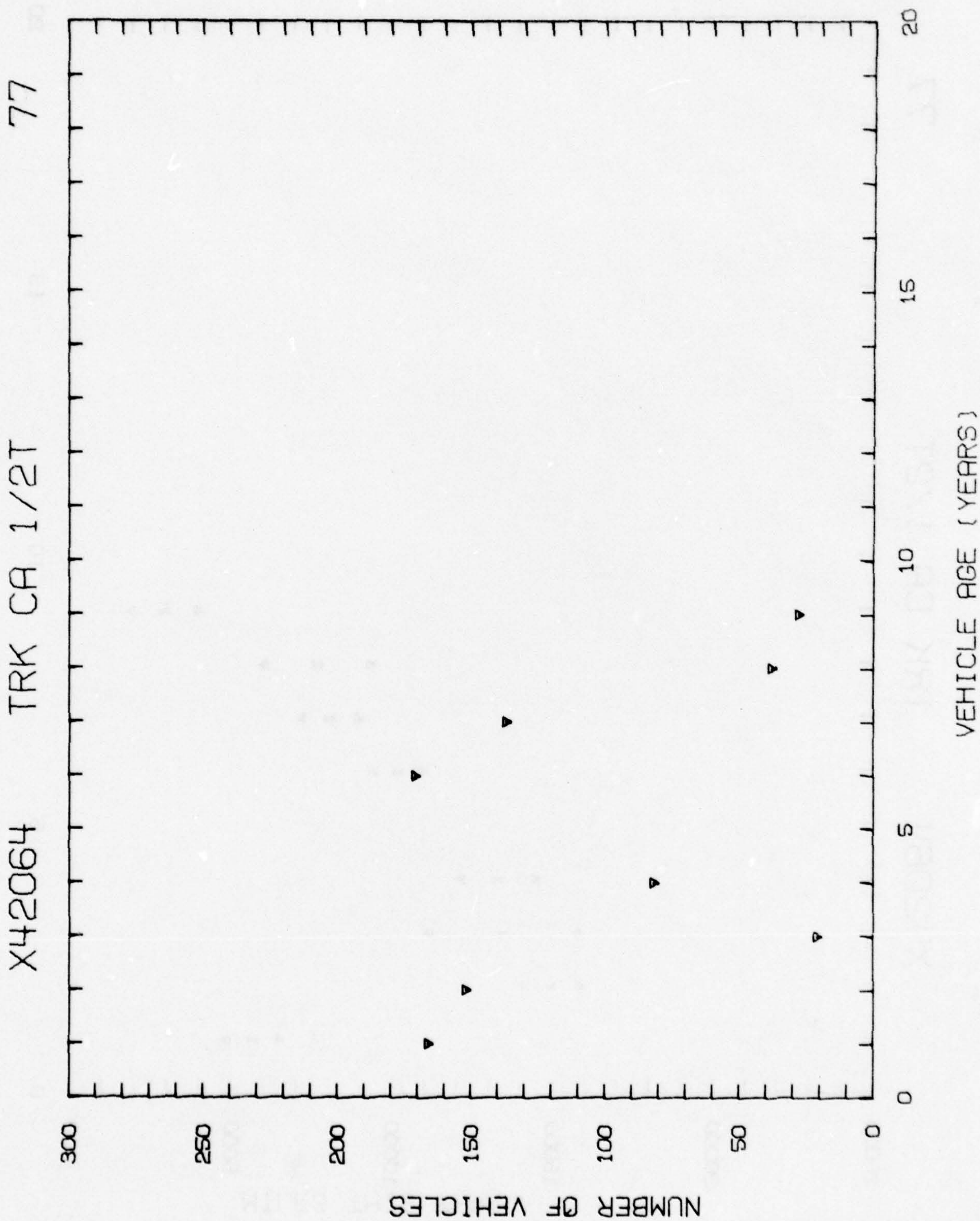
$= 5.61 + 4.32Y$

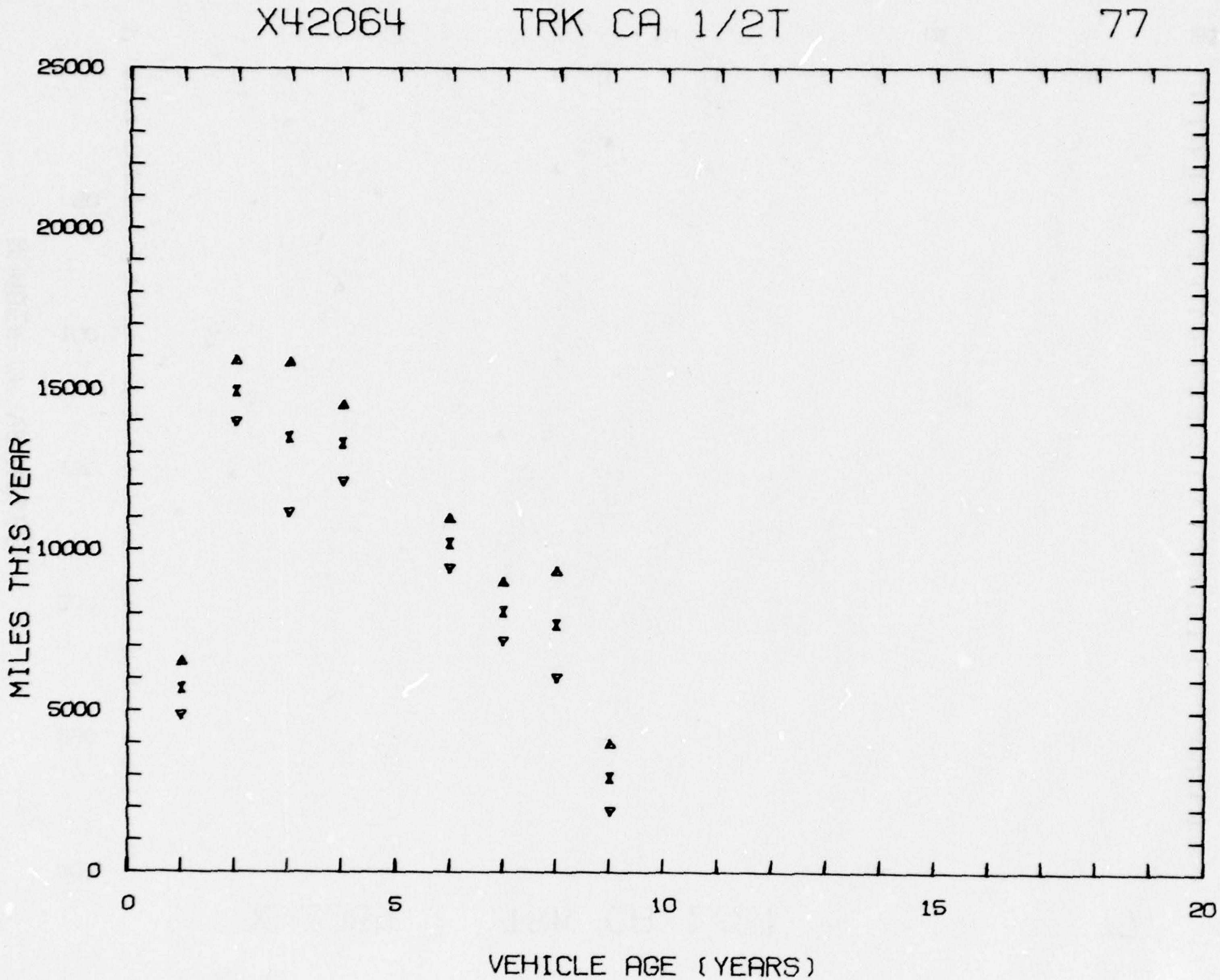
RSD = 15

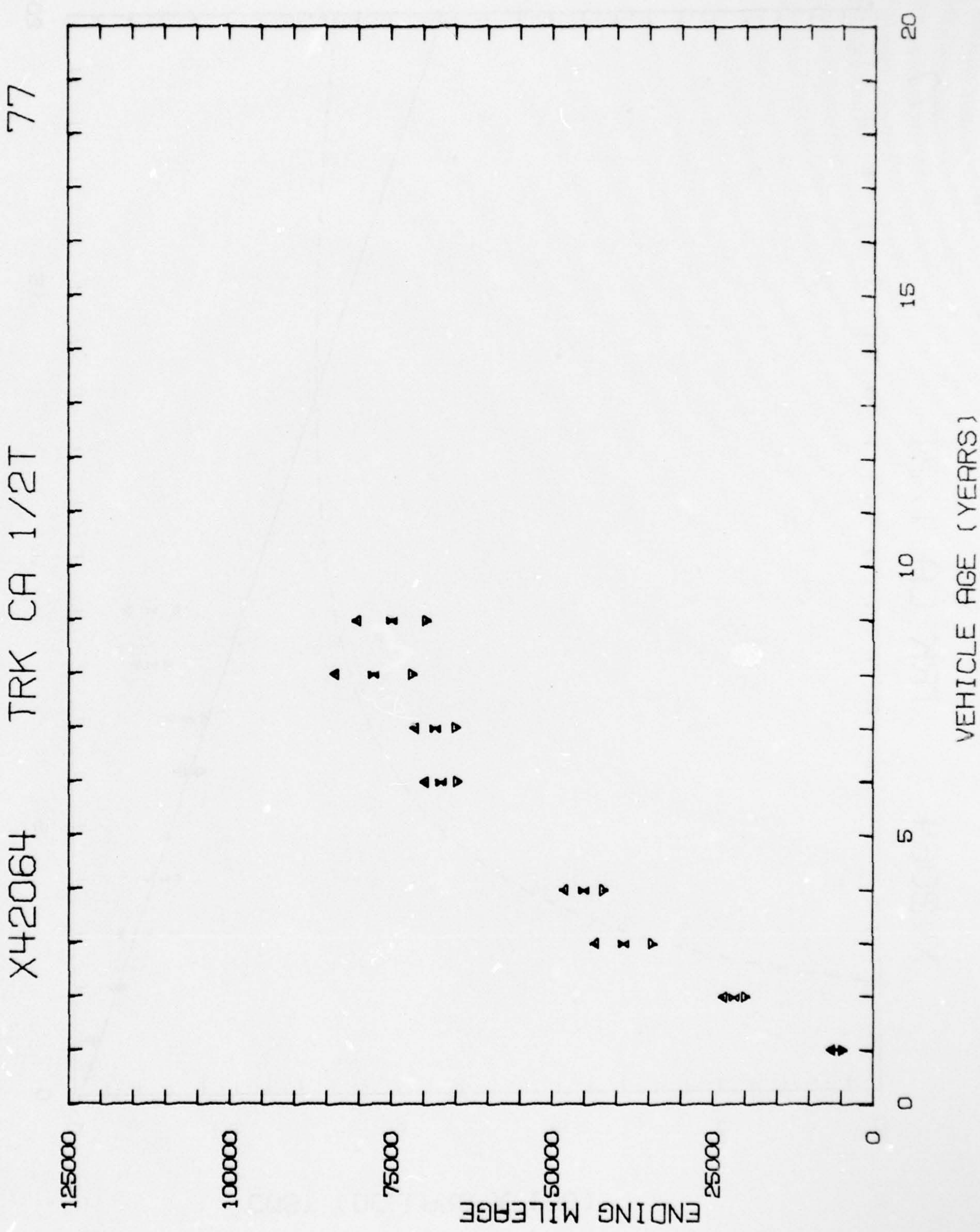
for each 1000 miles more than 10,000 add .7 hours

less 10,000 subtract .7

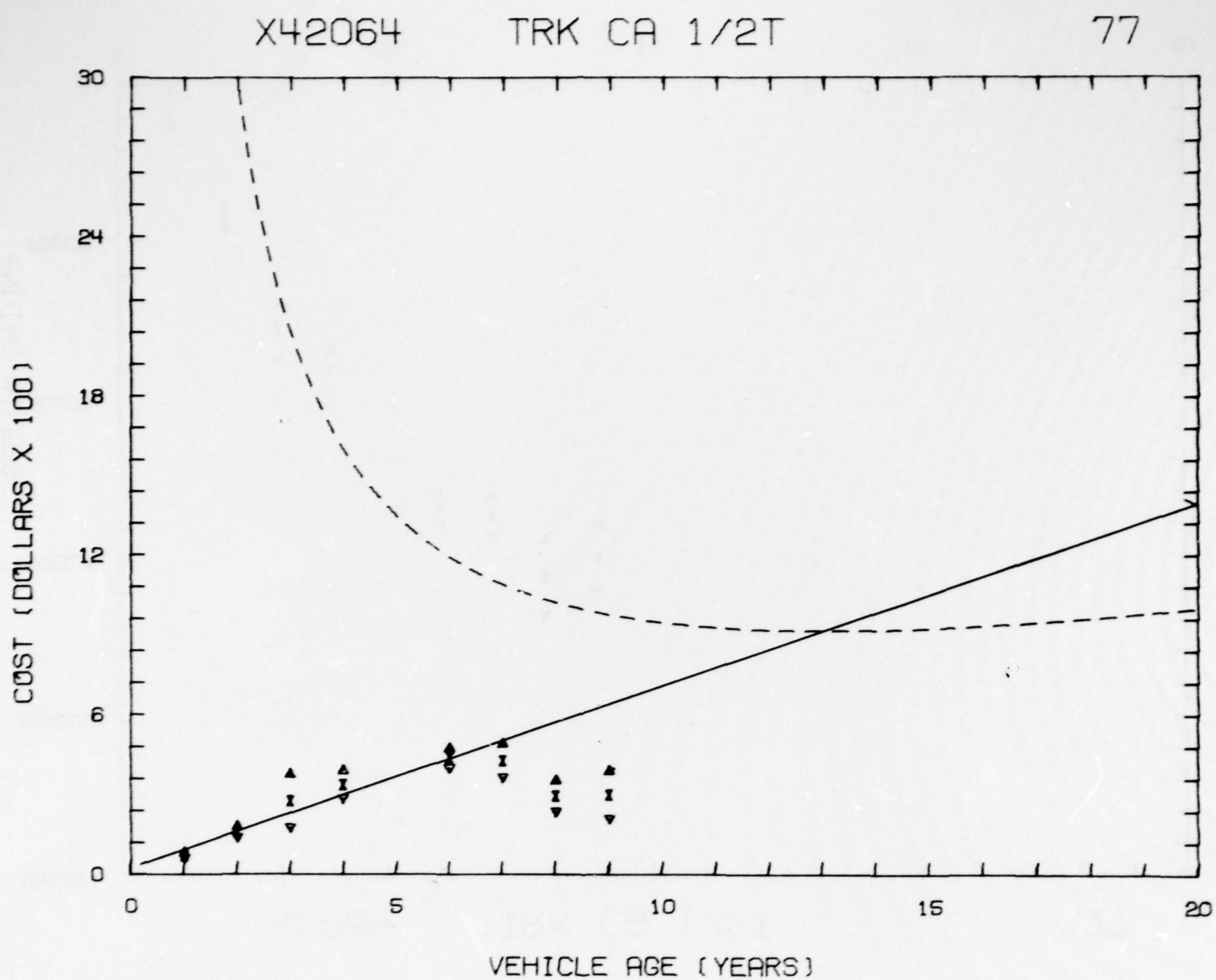
COMMENTS:

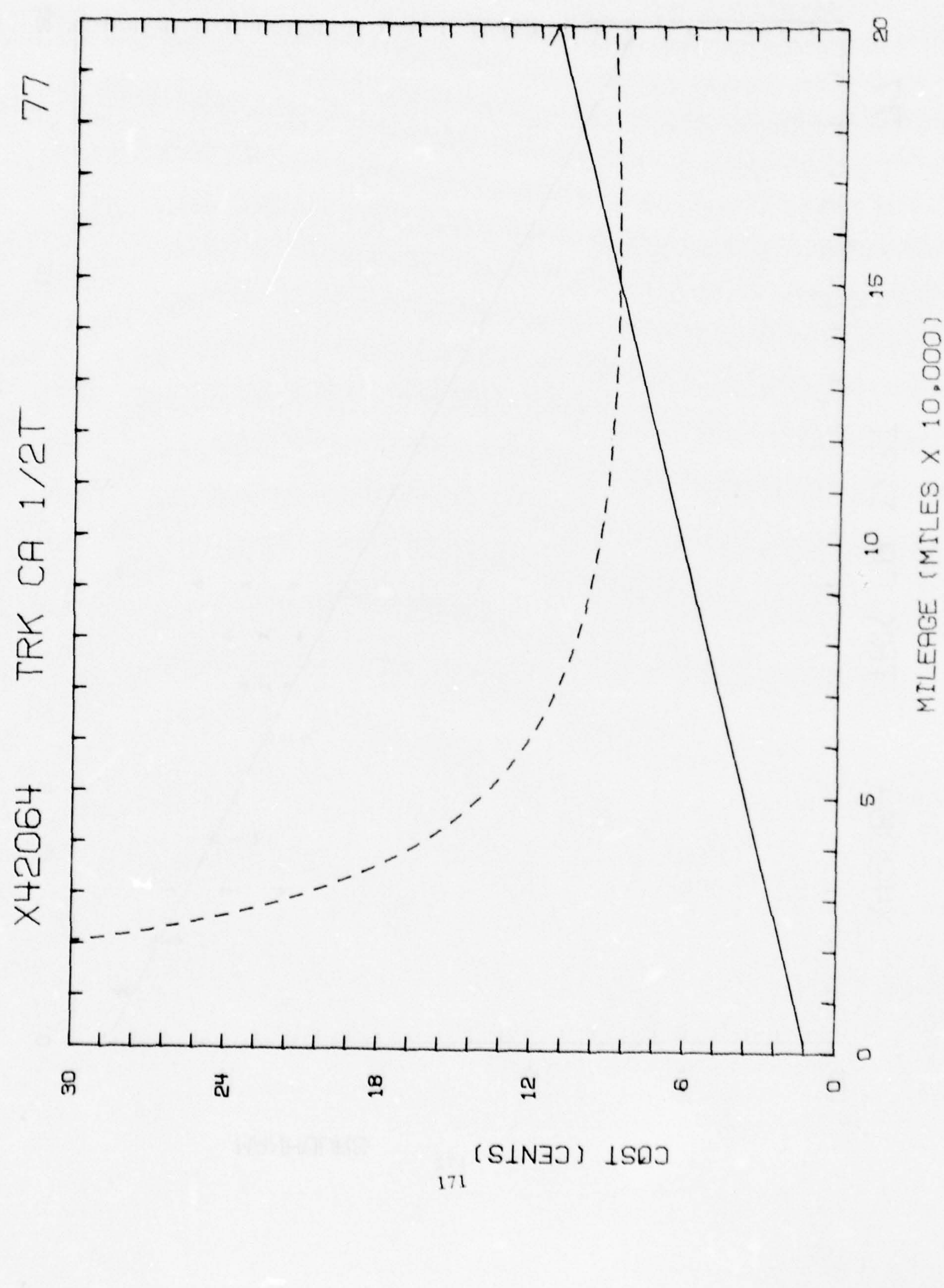

X42064 TRK CA 1/2T 77
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20

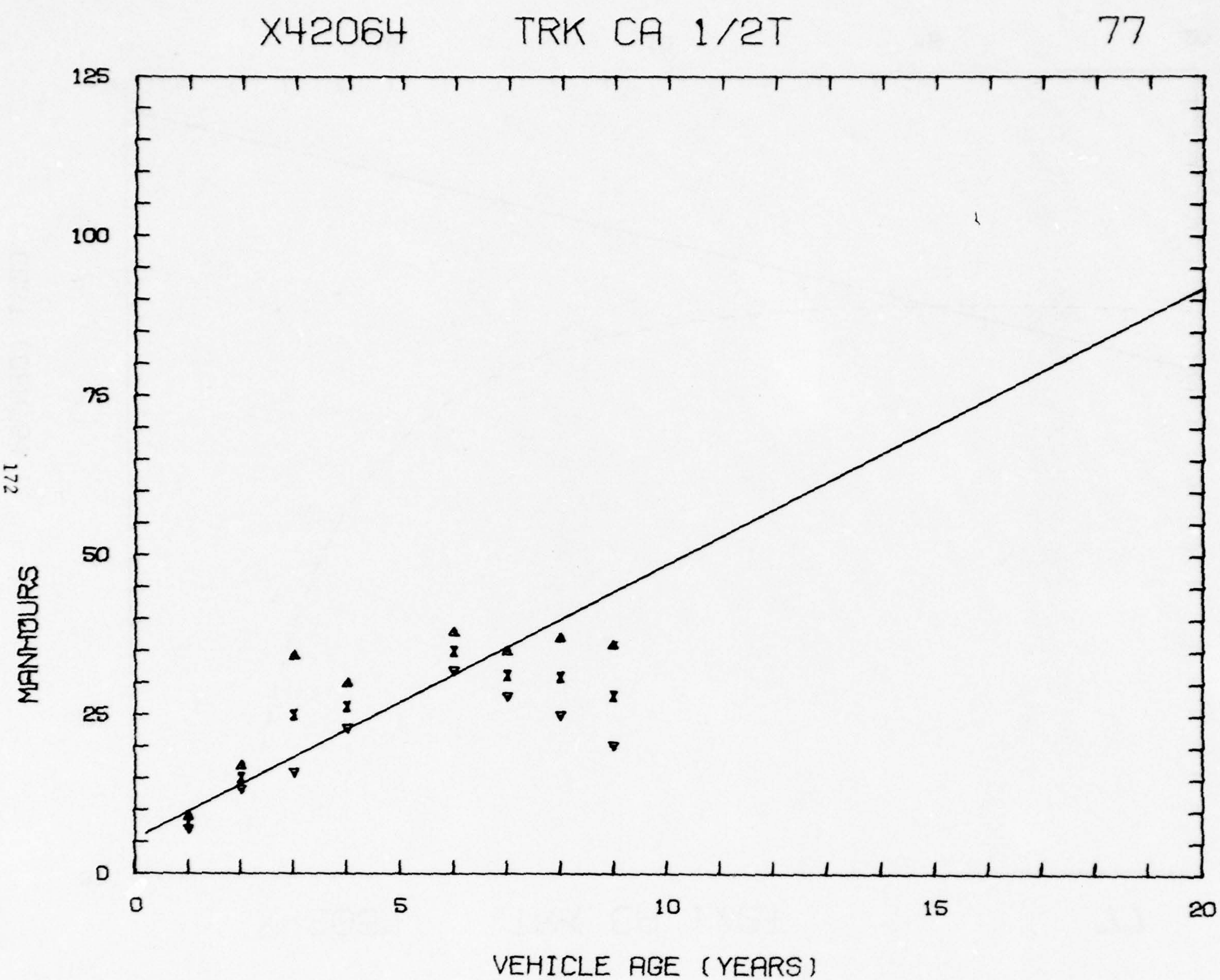

X42064 TRK CA 1/2T 77
MILES THIS YEAR
25000
20000
15000
10000
5000
0
0
5
10
15
20
VEHICLE AGE (YEARS)



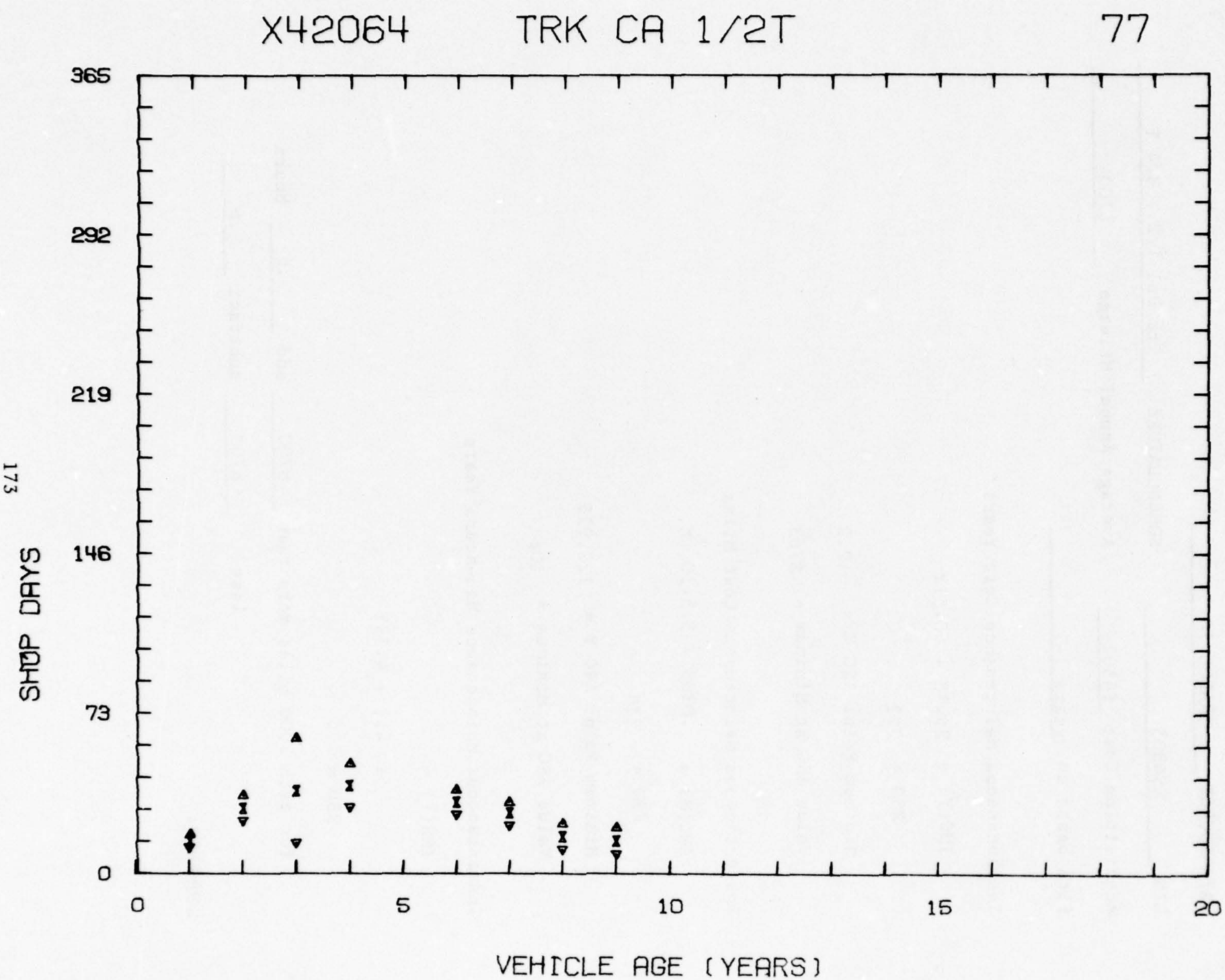
X42064 TRK CA 1/2T 77
ENDING MILEAGE
125000
100000
75000
50000
25000
0
VEHICLE AGE (YEARS)
0
5
10
15
20


X42064 TRK CA 1/2T 77
COST (DOLLARS X 100)
30
24
18
12
6
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X42064
TRK CA 1/2T
77
COST (CENTS)
30
24
18
12
6
0
0
5
10
15
20
MILEAGE (MILES X 10,000)



X42064 TRK CA 1/2T 77
MANHOURS
VEHICLE AGE (YEARS)
0
5
10
15
20
25
50
75
100
125


X42064
TRK CA 1/2T
77
SHOP DAYS
365
292
219
146
73
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 78

LIN X54805 NOMENCLATURE Trk Pnl 1/2 - 3/4 T

Acquisition Cost $4501 Average Annual Mileage 6700

Fits based on years 1-7

Instantaneous Maintenance Cost Years

IMC(Y) = 25.18 + 60.51Y

RSD = 222

Minimum Point ASC Y = 12.2

Value ASC at Minimum = $763

Instantaneous Maintenance Cost Miles

IMC(M) = $.0308 + 5.5 \cdot 10^{-7} M$

RSD = 238

Minimum Point ASC Y = 127,935

Value ASC at Minimum = 10¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

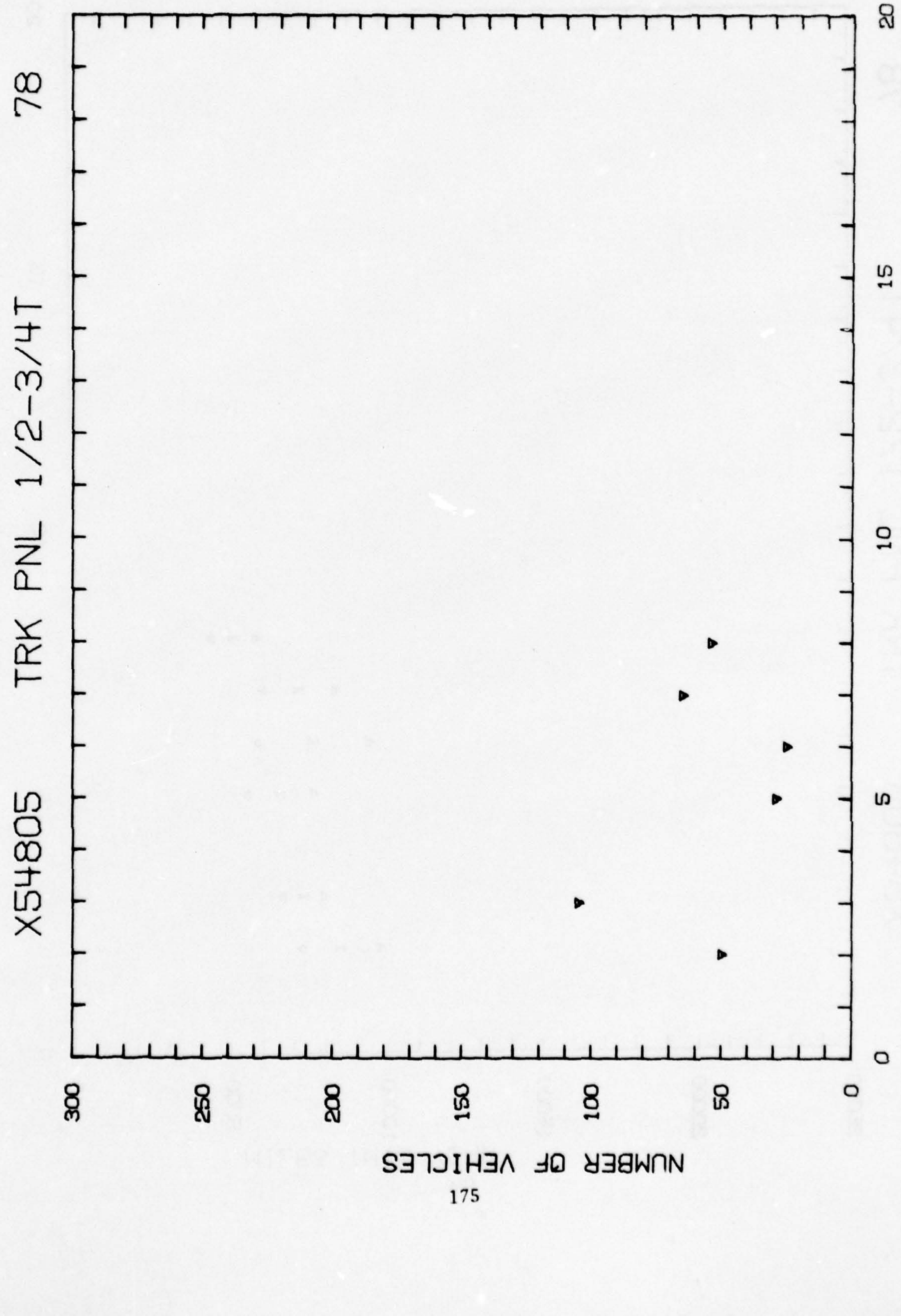
= 4.1 + 4.33Y

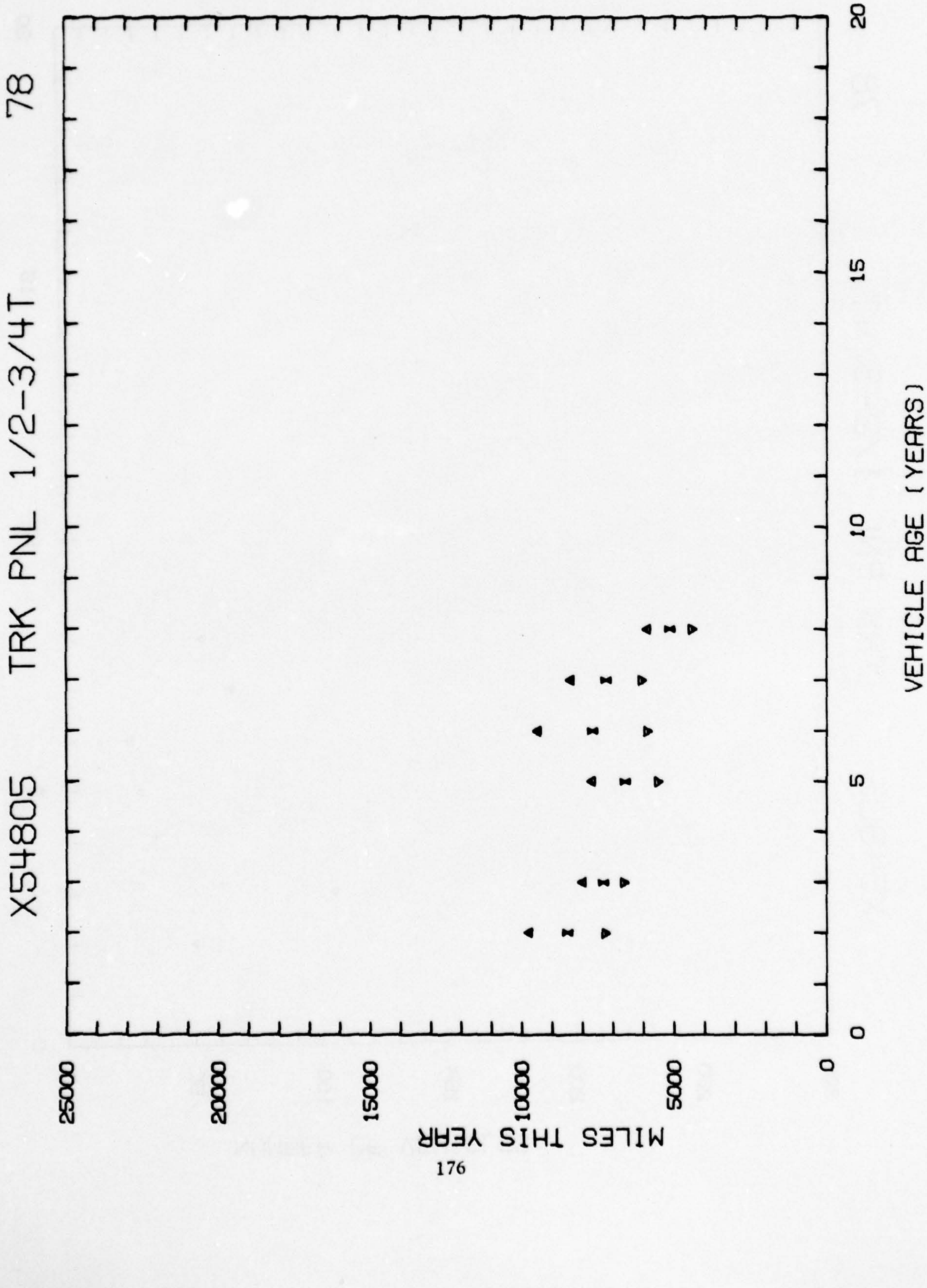
RSD = 16

for each 1000 miles more than 6700 add .6 hours

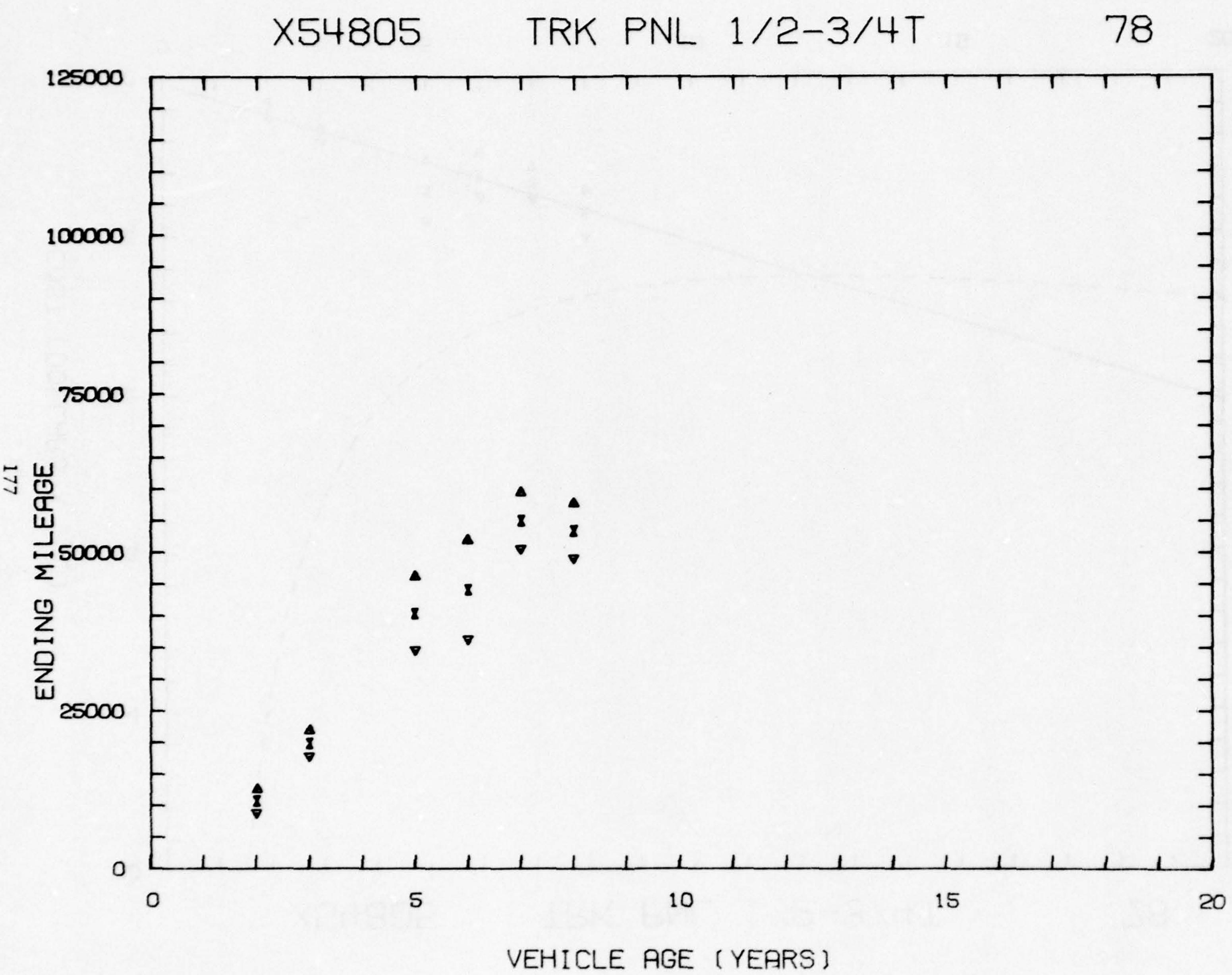
less 6700 subtract .6

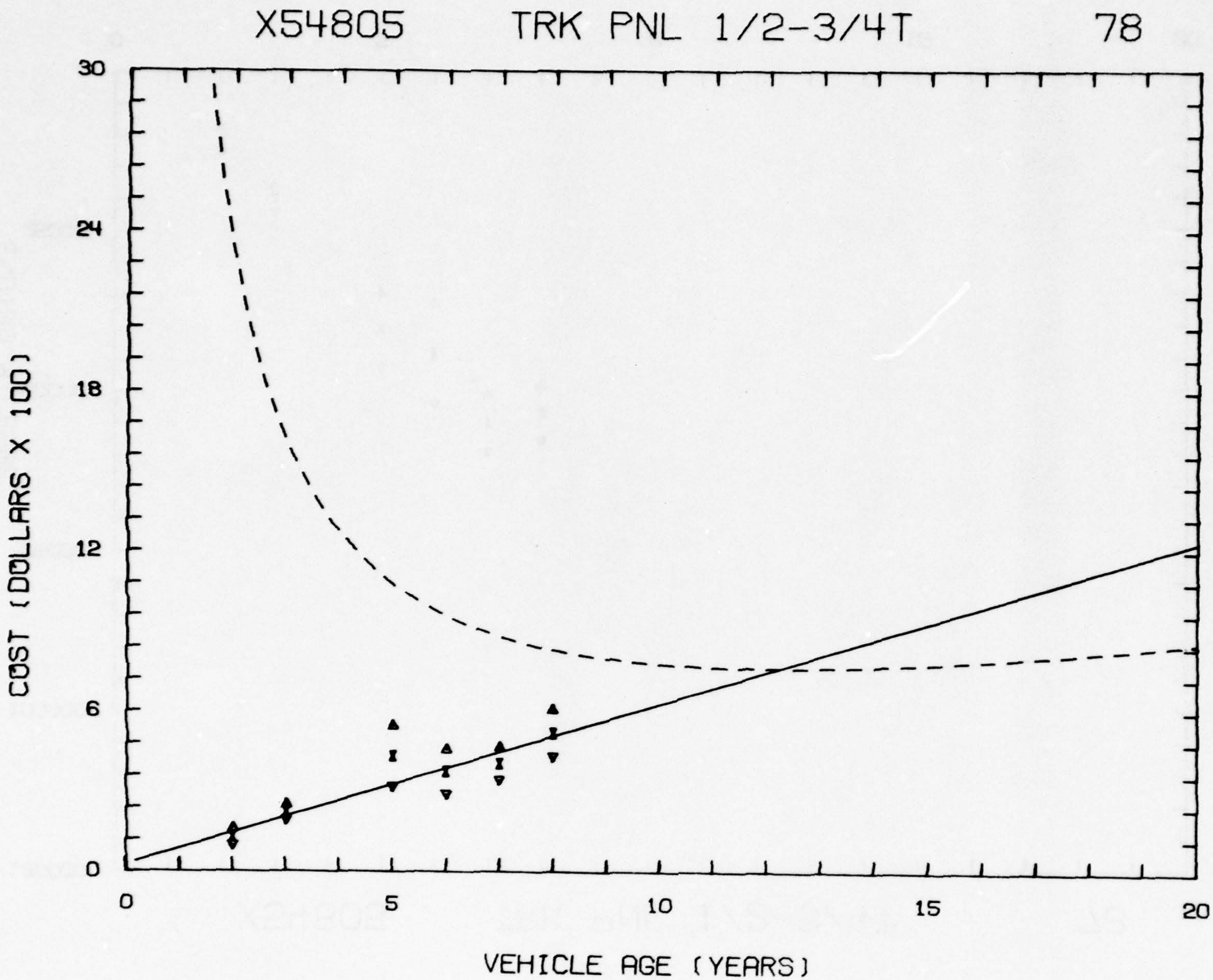
COMMENTS:

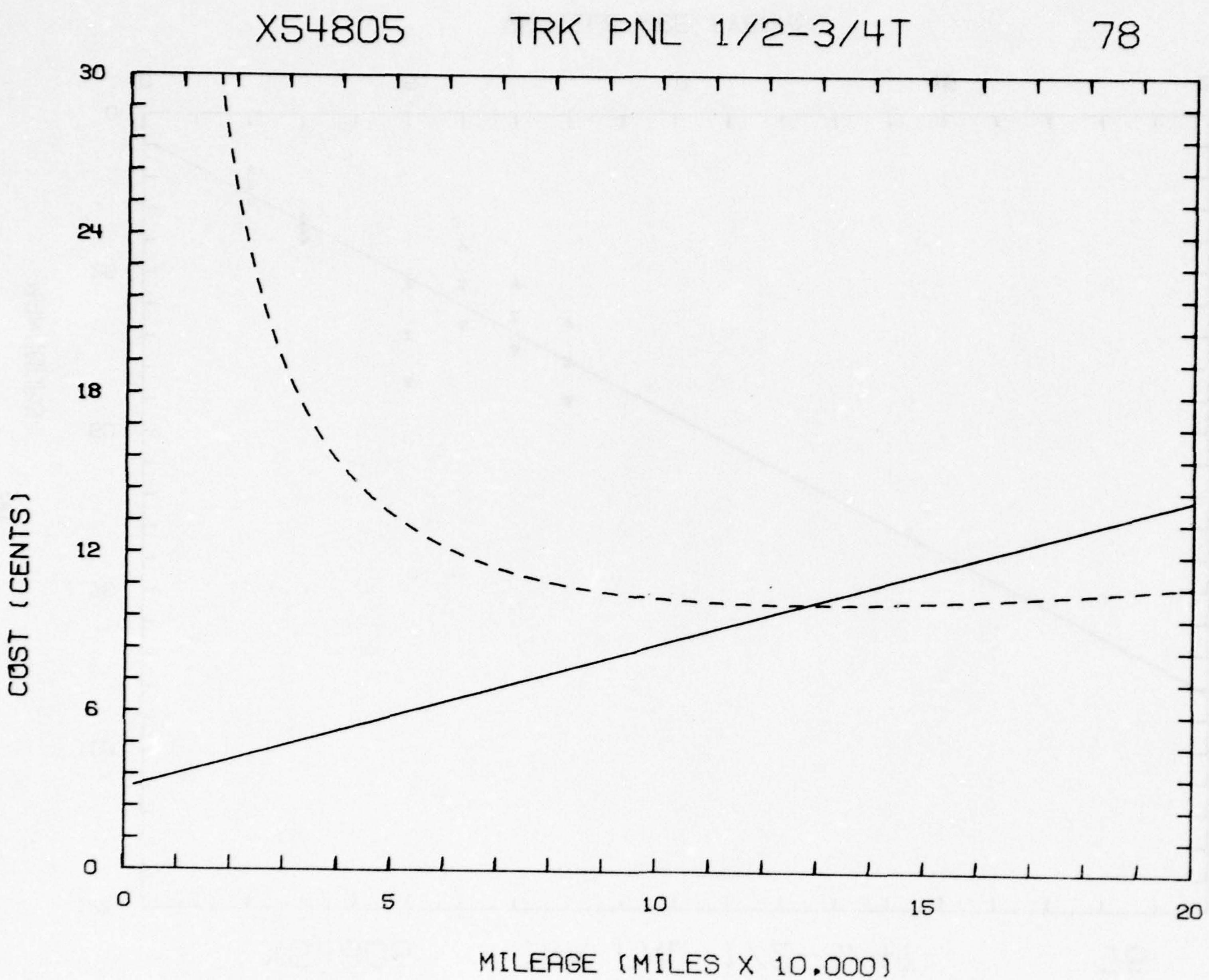

X54805 TRK PNL 1/2-3/4T 78
NUMBER OF VEHICLES
300
250
200
150
100
50
0
VEHICLE AGE (YEARS)
0
5
10
15
20

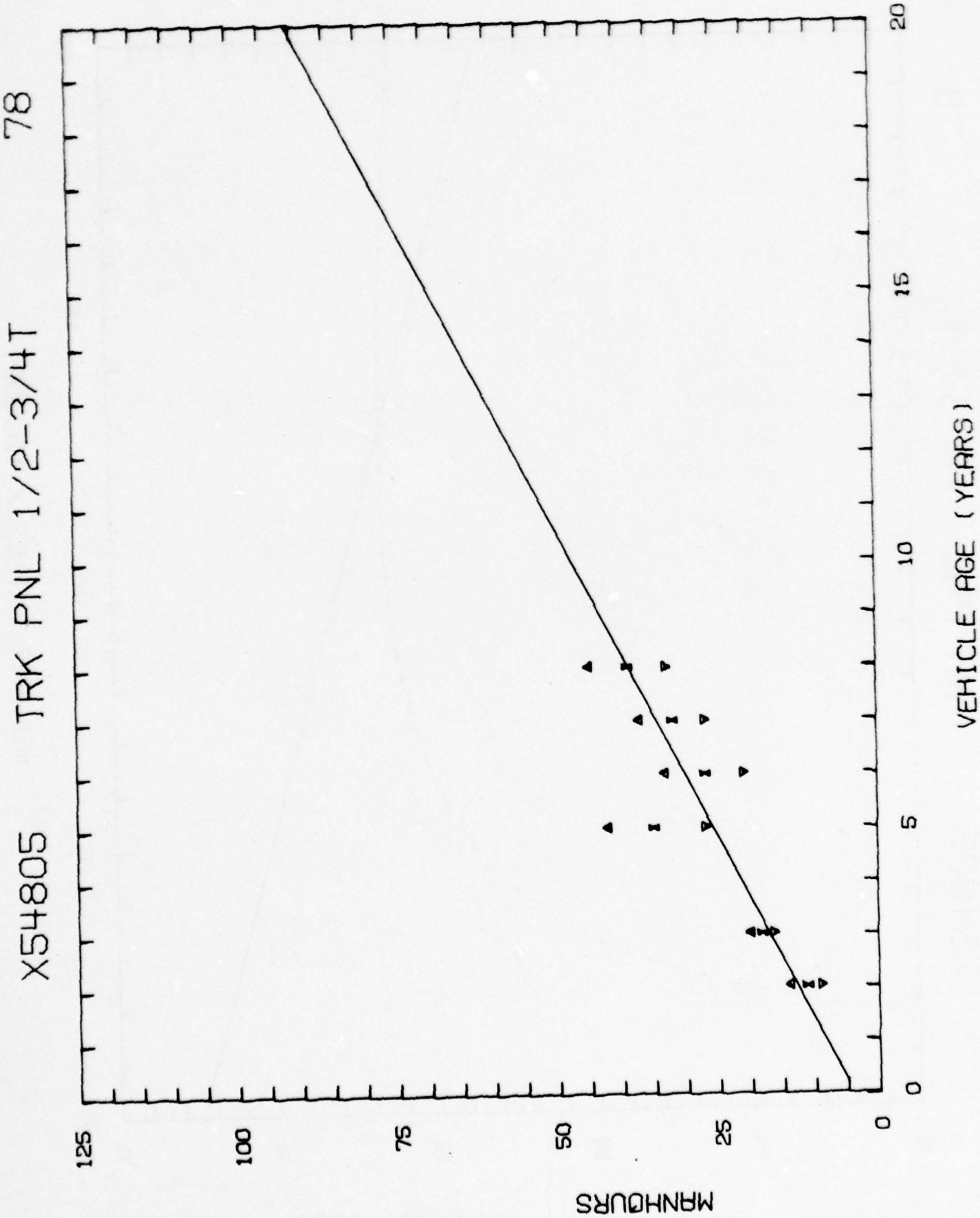


X54805 TRK PNL 1/2-3/4T 78
MILES THIS YEAR
25000
20000
15000
10000
5000
0
VEHICLE AGE (YEARS)
0
5
10
15
20

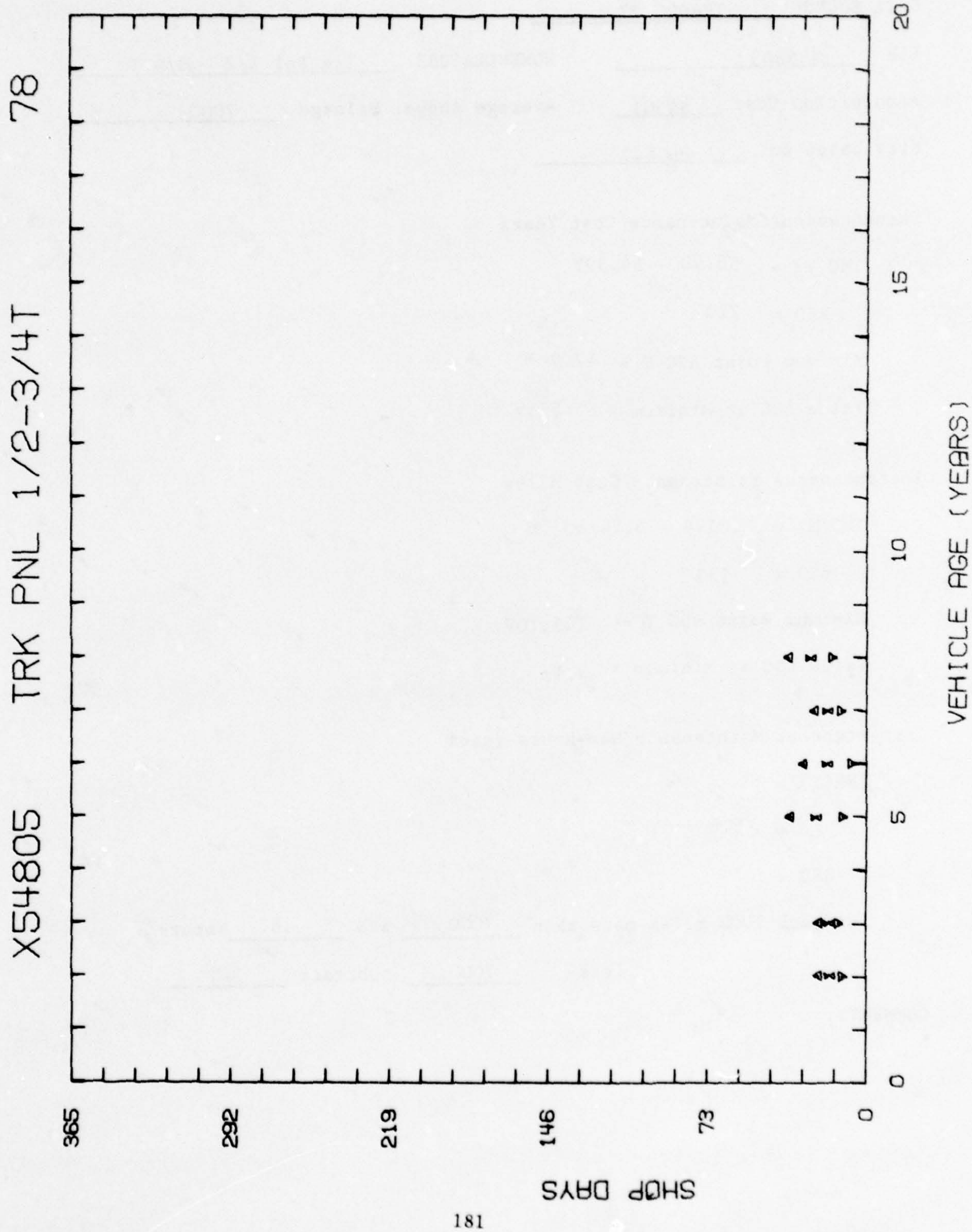

X54805
TRK PNL 1/2-3/4T
78
ENDING MILEAGE
125000
100000
75000
50000
25000
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X54805 TRK PNL 1/2-3/4T 78
COST (DOLLARS X 100)
VEHICLE AGE (YEARS)
0
6
12
18
24
30
0
5
10
15
20


X54805 TRK PNL 1/2-3/4T 78
COST (CENTS)
0
6
12
18
24
30
MILEAGE (MILES X 10.000)
0
5
10
15
20



X54805 TRK PNL 1/2-3/4T 78
MANHOURS
0
25
50
75
100
125
VEHICLE AGE (YEARS)
0
5
10
15
20


X54805 TRK PNL 1/2-3/4T 78
SHOP DAYS
365
292
219
146
73
0
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN X54805 NOMENCLATURE Trk Pnl 1/2 - 3/4 T

Acquisition Cost $4501 Average Annual Mileage 7000

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 58.90 + 54.39Y$

RSD = 220

Minimum Point ASC Y = 12.9

Value ASC at Minimum = $759

Instantaneous Maintenance Cost Miles

$IMC(M) = .0294 + 4.24 \cdot 10^{-7} M$

RSD = 235

Minimum Point ASC Y = 145,709

Value ASC at Minimum = 9.1¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

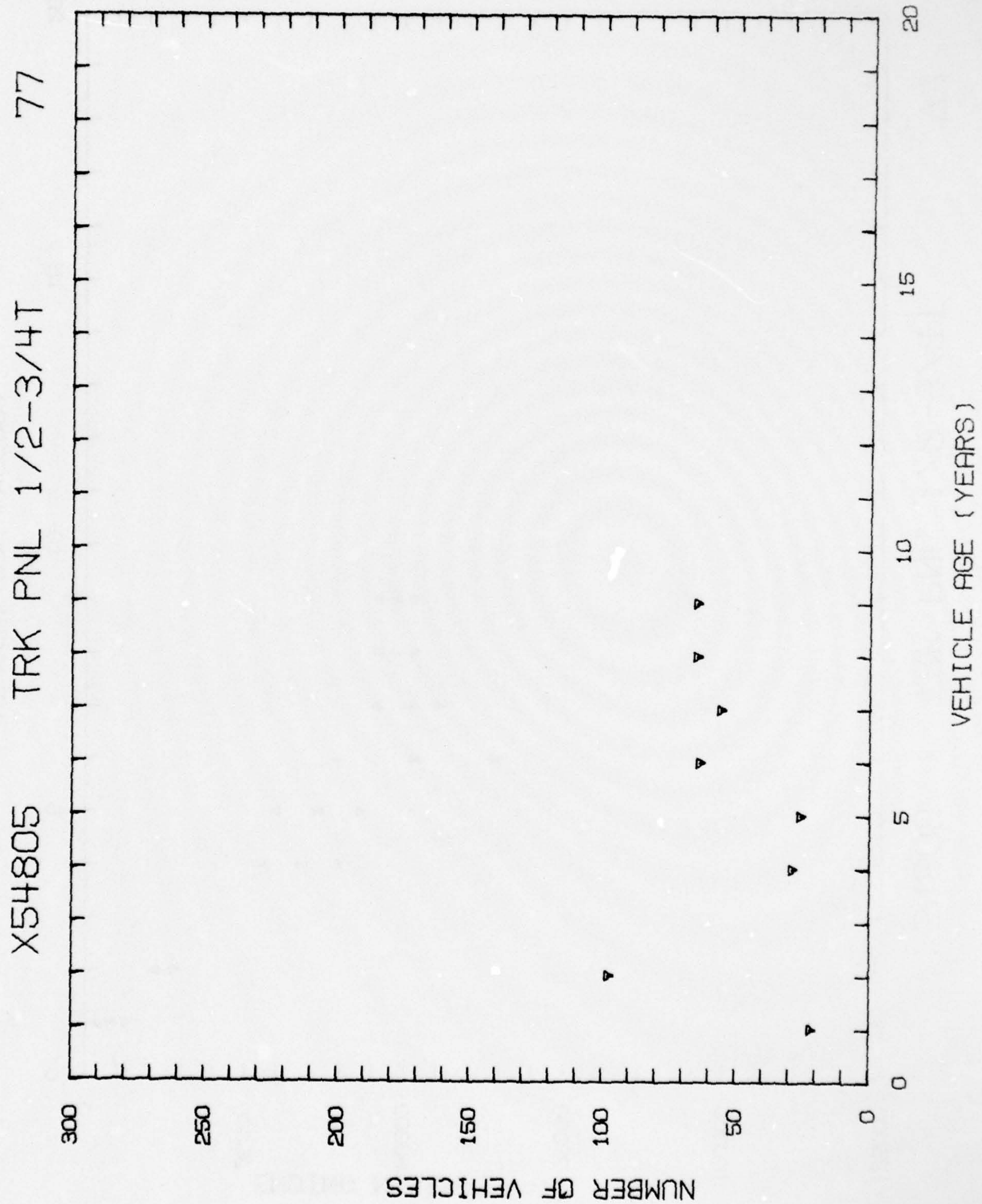
$= 5.6 + 4Y$

RSD = 14

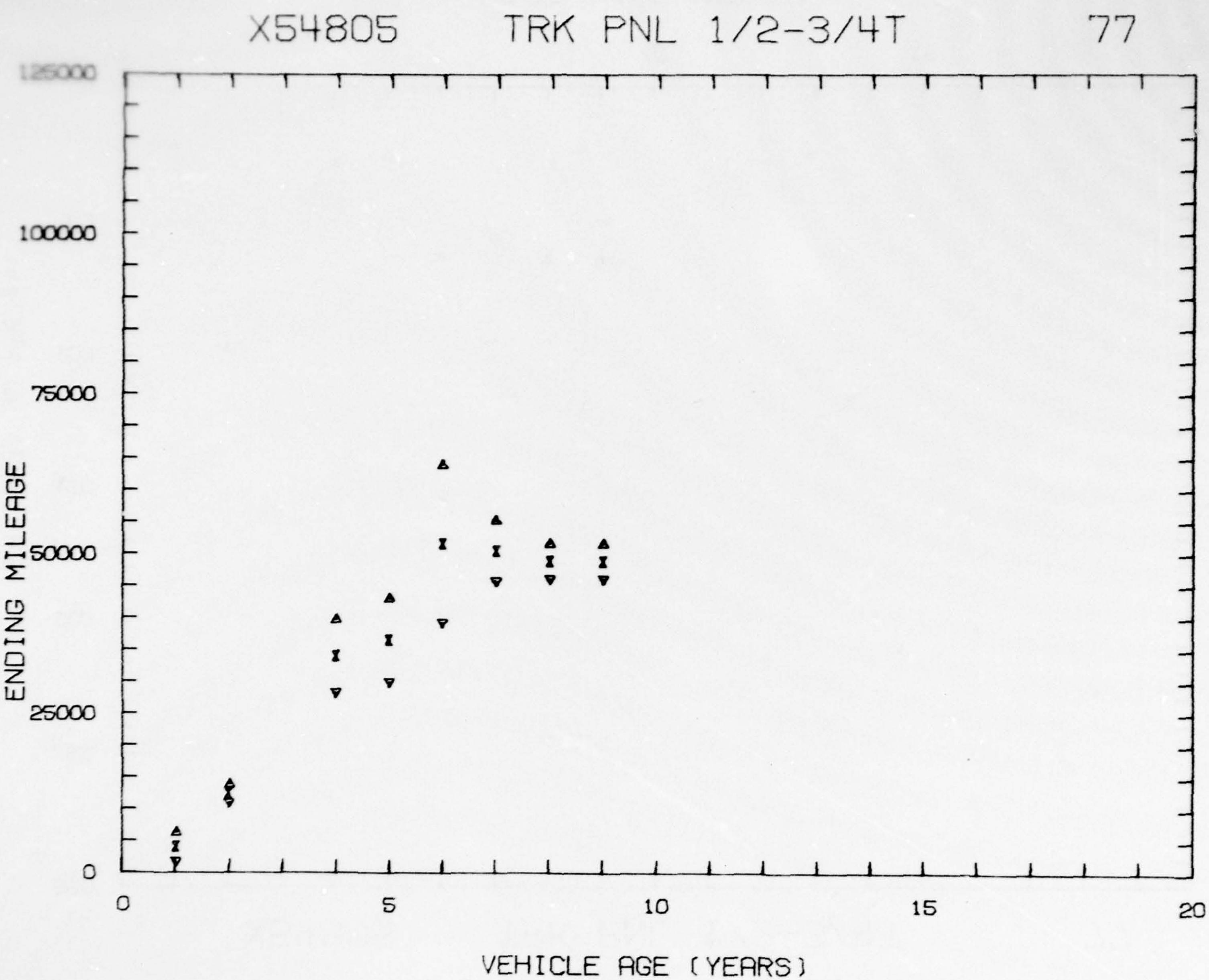
for each 1000 miles more than 7000 add .8 hours

less 7000 subtract .8

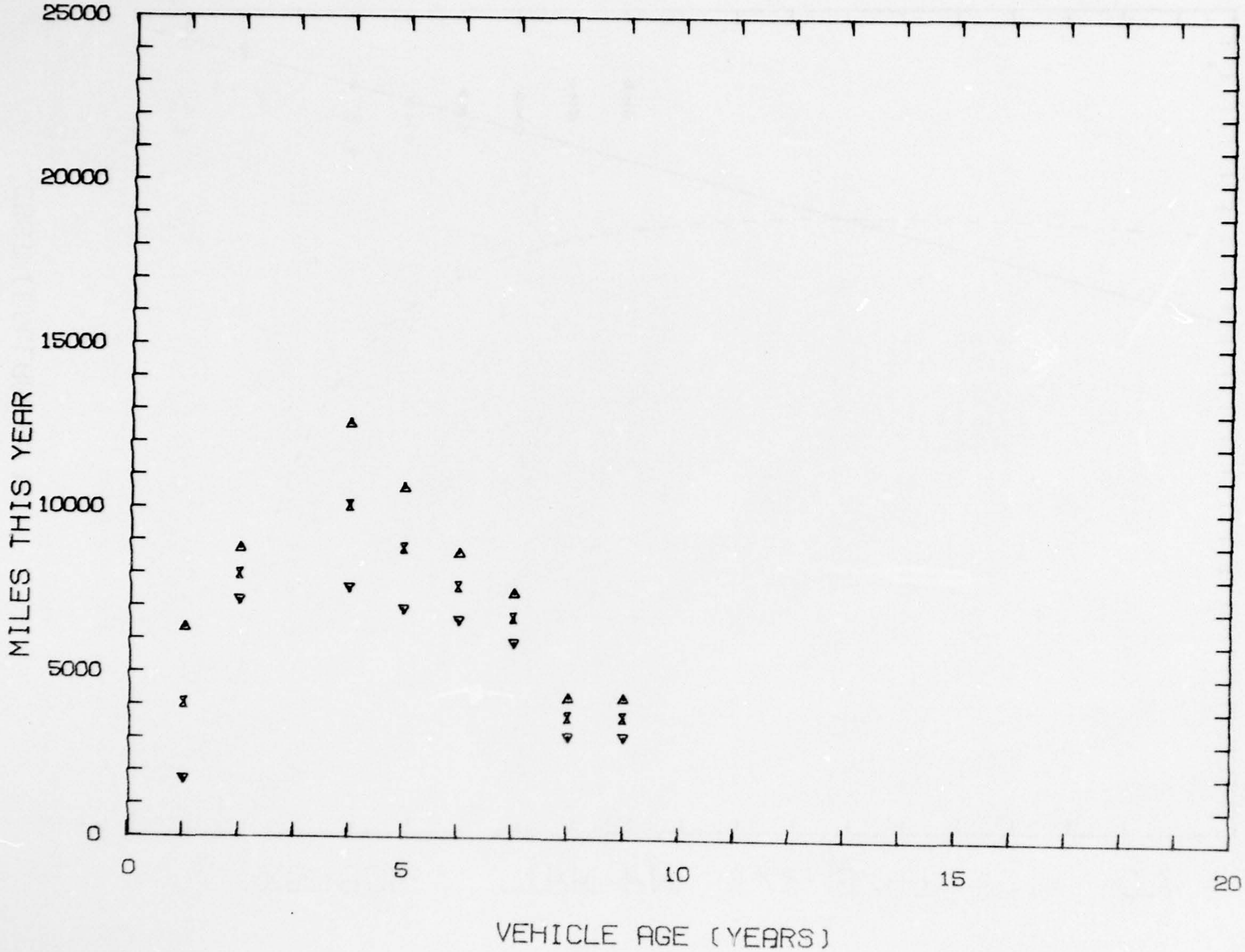
COMMENTS:

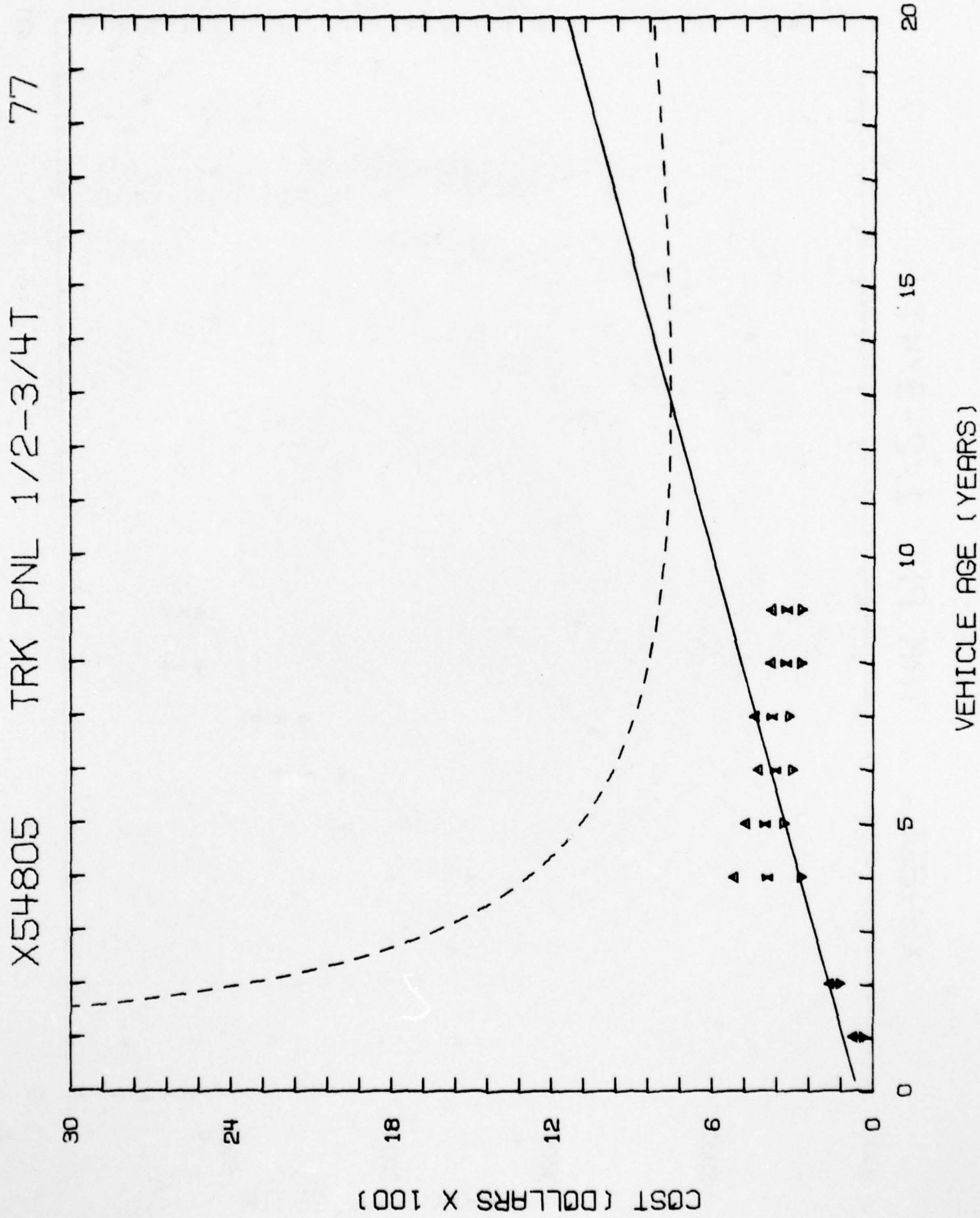


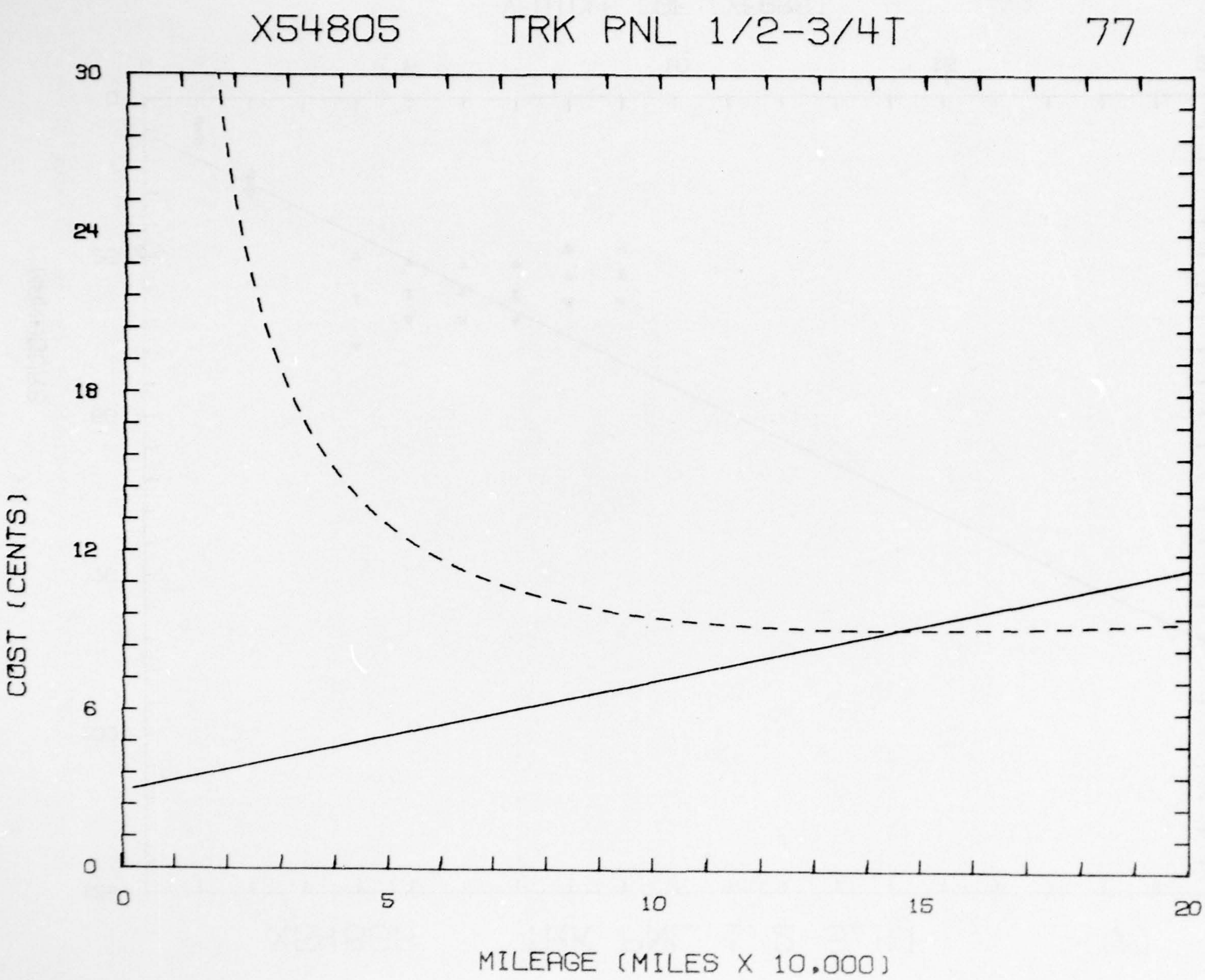
X54805 TRK PNL 1/2-3/4T 77
NUMBER OF VEHICLES
VEHICLE AGE (YEARS)
0
50
100
150
200
250
300
0
5
10
15
20

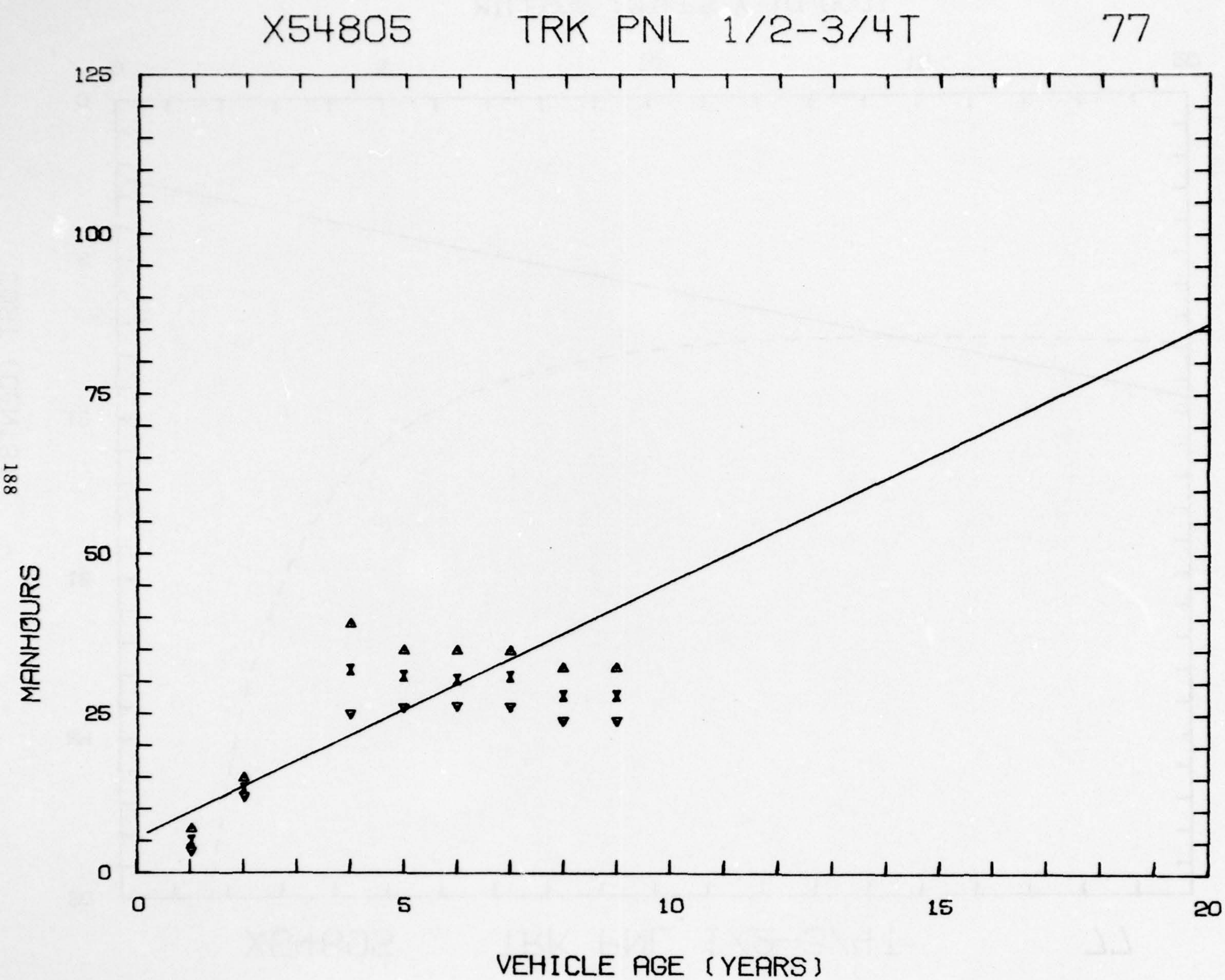

X54805 TRK PNL 1/2-3/4T 77
ENDING MILEAGE
125000
100000
75000
50000
25000
0
0
5
10
15
20
VEHICLE AGE (YEARS)

X54805 TRK PNL 1/2-3/4T 77

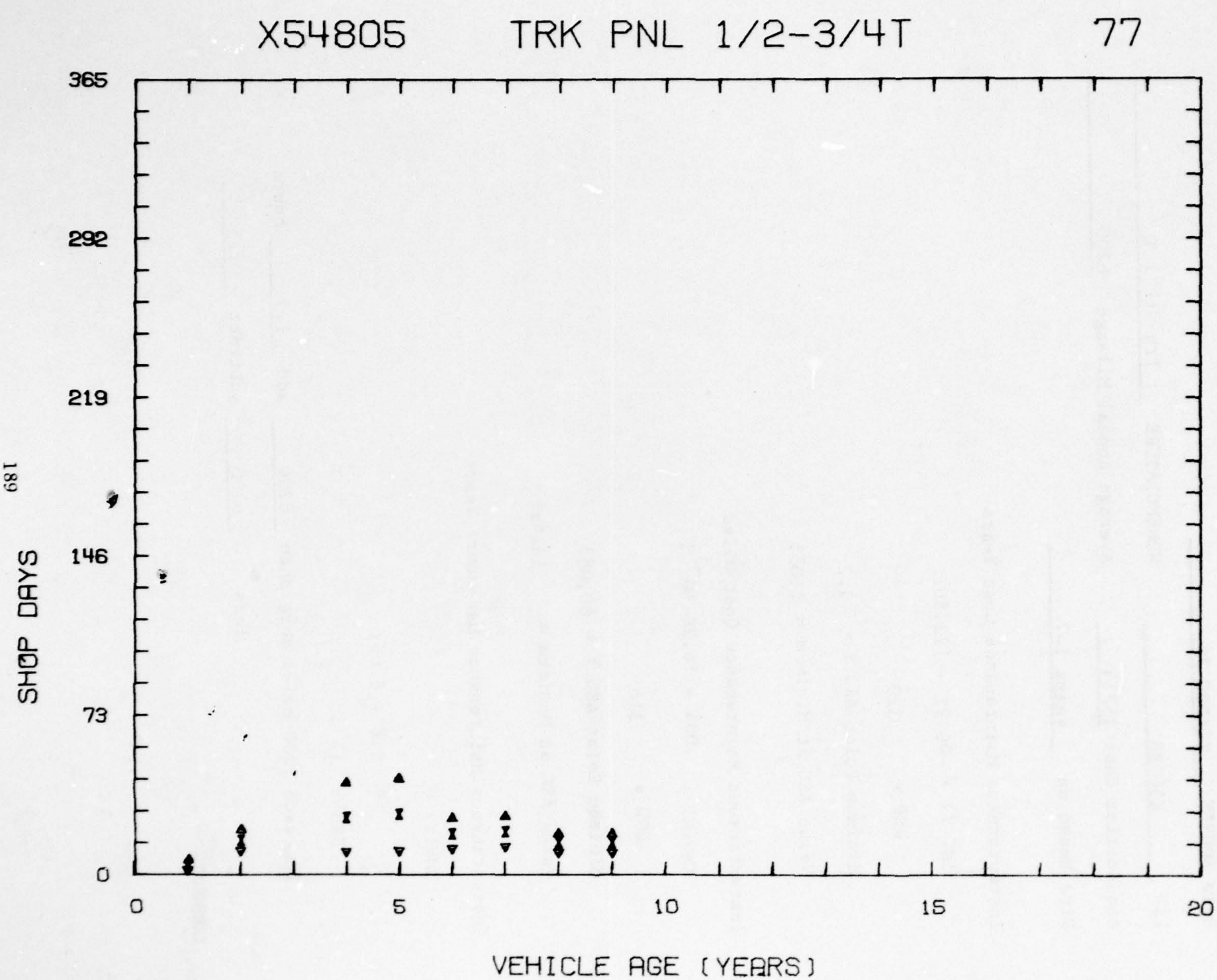



X54805 TRK PNL 1/2-3/4T 77
COST (DOLLARS X 100)
30
24
18
12
6
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X54805 TRK PNL 1/2-3/4T 77
COST (CENTS)
0
6
12
18
24
30
0
5
10
15
20
MILEAGE (MILES X 10,000)



X54805 TRK PNL 1/2-3/4T 77
MANHOURS
125
100
75
50
25
0
5
10
15
20
VEHICLE AGE (YEARS)



X54805 TRK PNL 1/2-3/4T 77
365
292
219
146
73
0
SHOP DAYS
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 78

LIN X56038 NOMENCLATURE Trk Stk 1 T

Acquisition Cost $5214 Average Annual Mileage 6200

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = -96.91 + 122.86Y$

RSD = 329

Minimum Point ASC Y = 9.2

Value ASC at Minimum = $1035

Instantaneous Maintenance Cost Miles

$IMC(M) = .034 + 16.26 \cdot 10^{-7} M$

RSD = 318

Minimum Point ASC Y = 80,083

Value ASC at Minimum = 16.4¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) =$

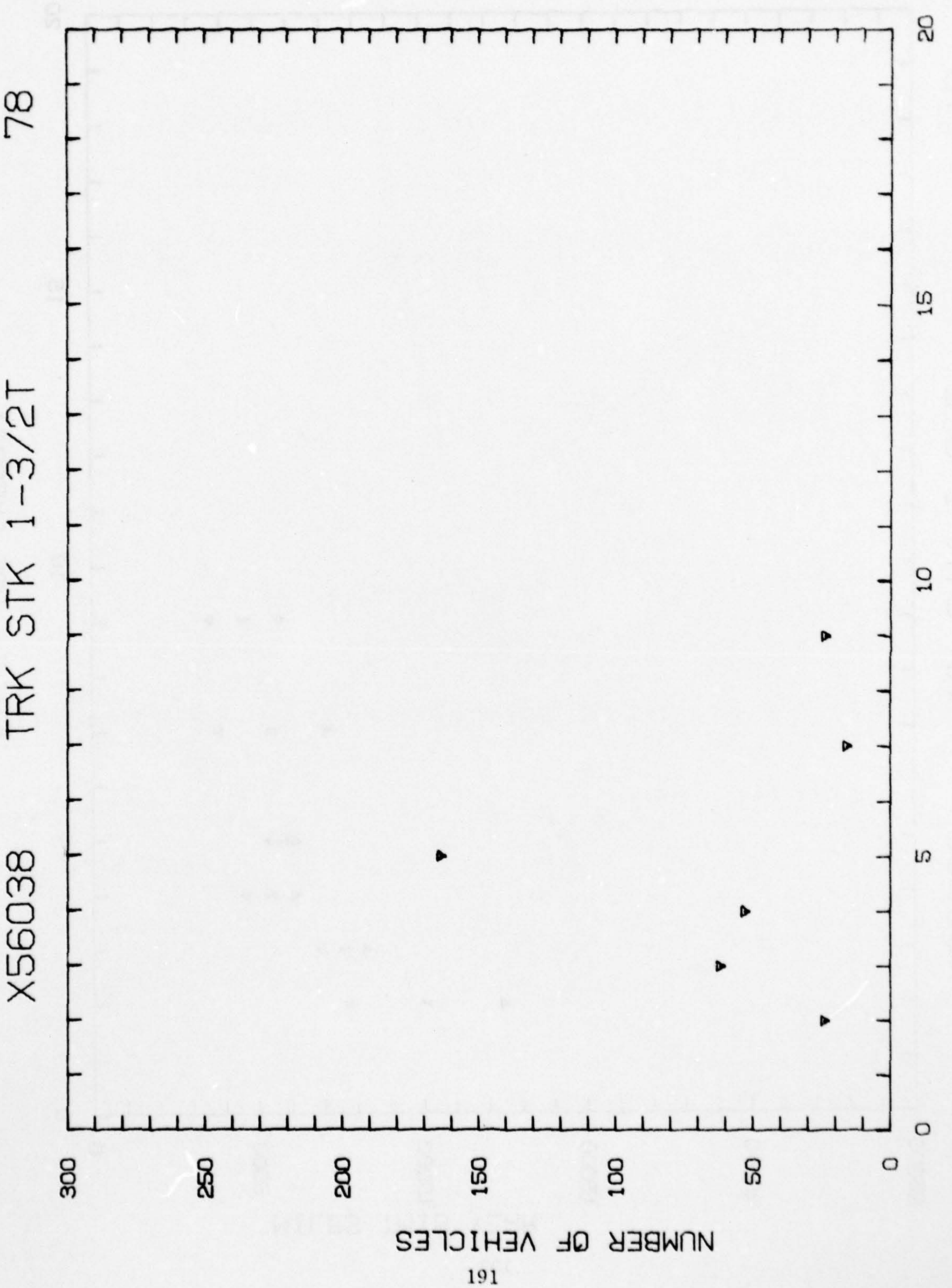
$= 5.8 + 8.66Y$

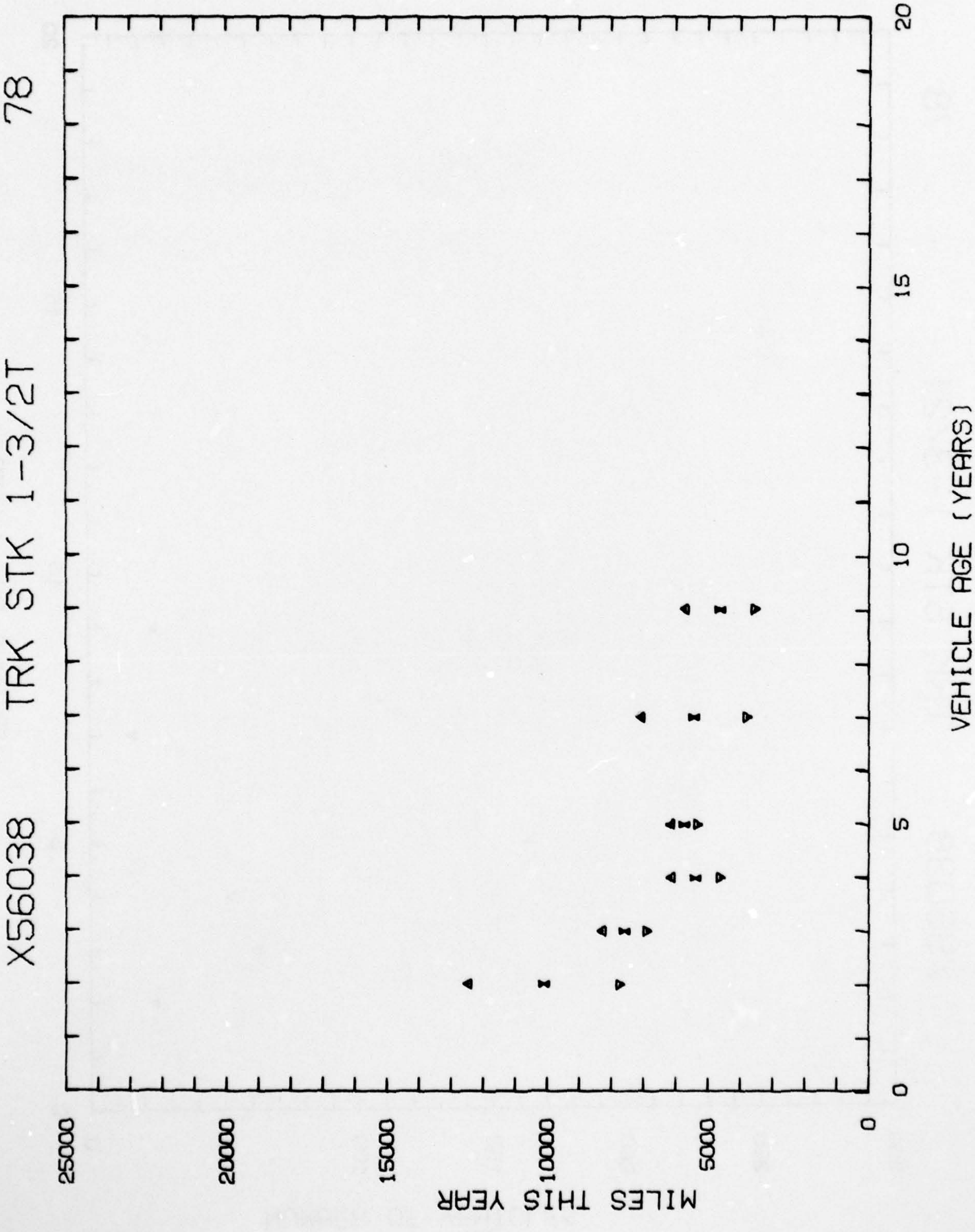
RSD = 18

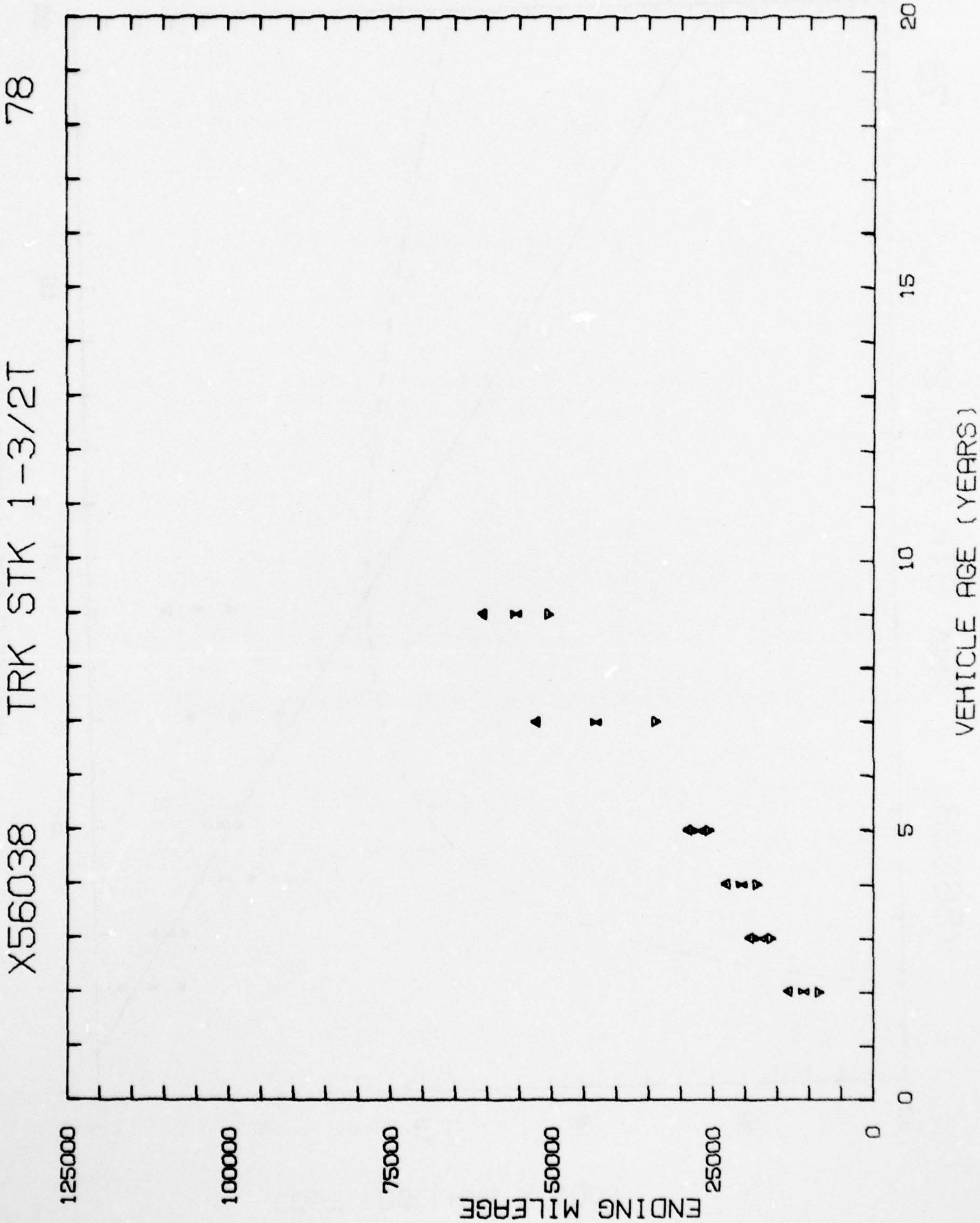
for each 1000 miles more than 6200 add 1.5 hours

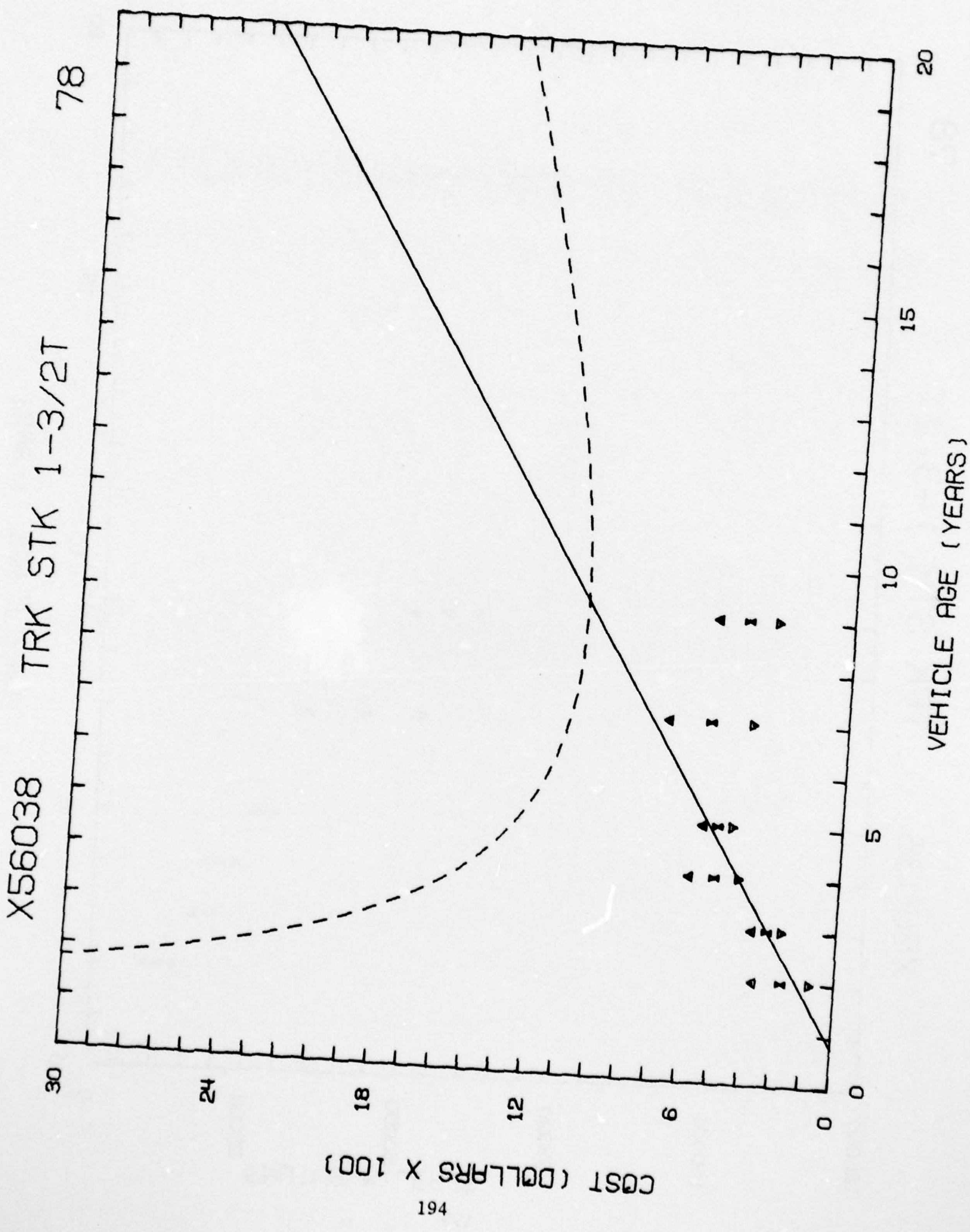
less 6200 subtract 1.5

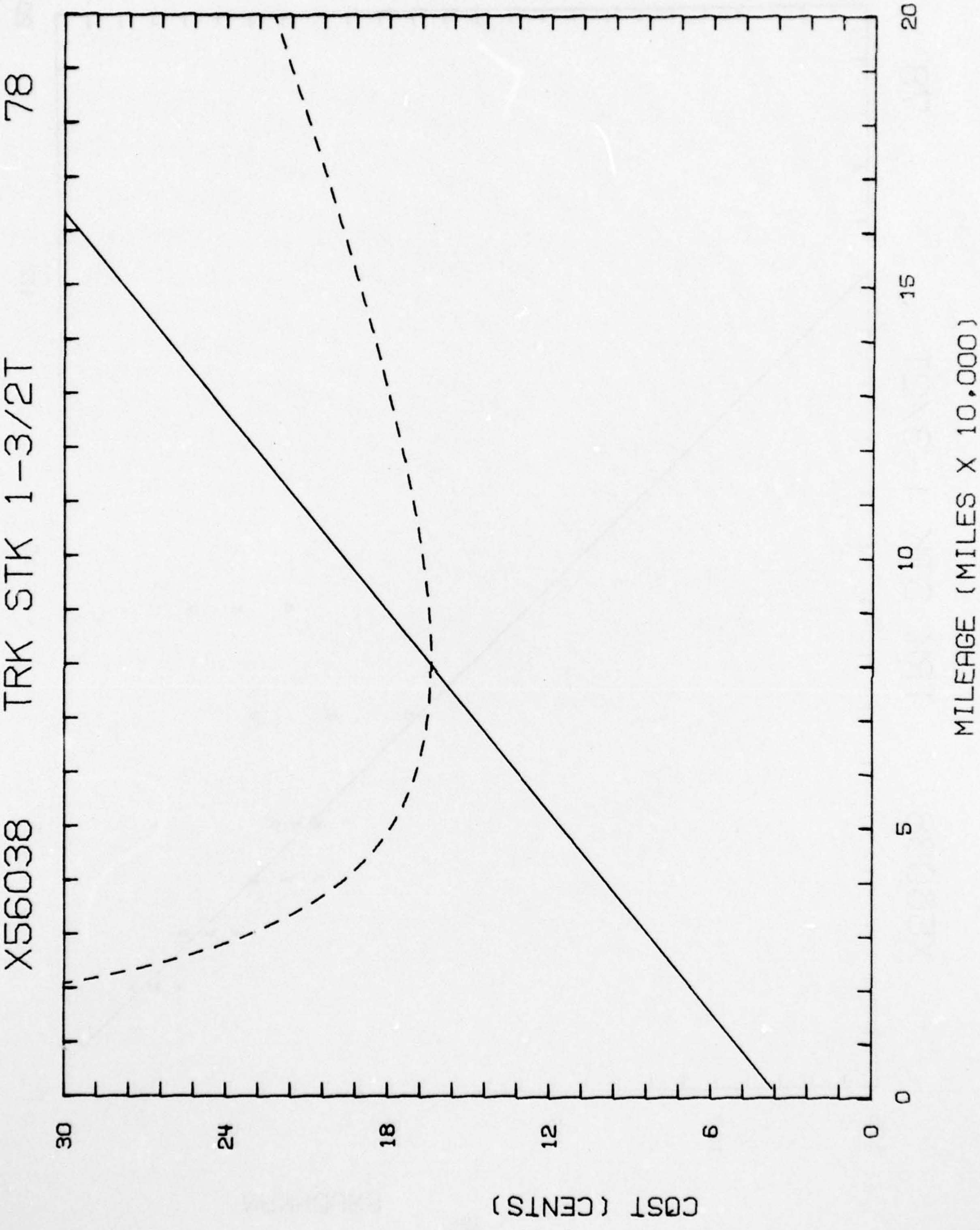
COMMENTS:

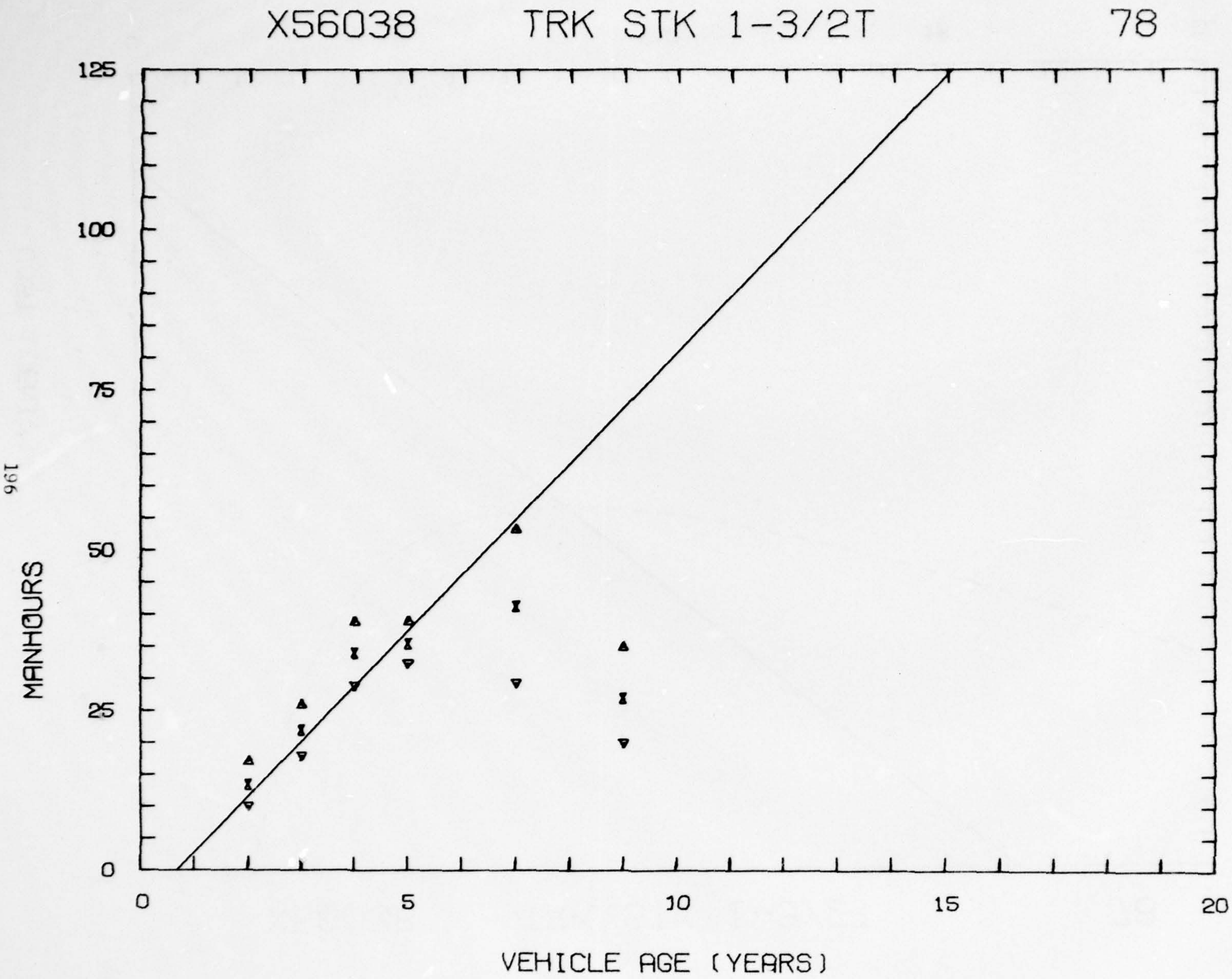

X56038 TRK STK 1-3/2T 78
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20

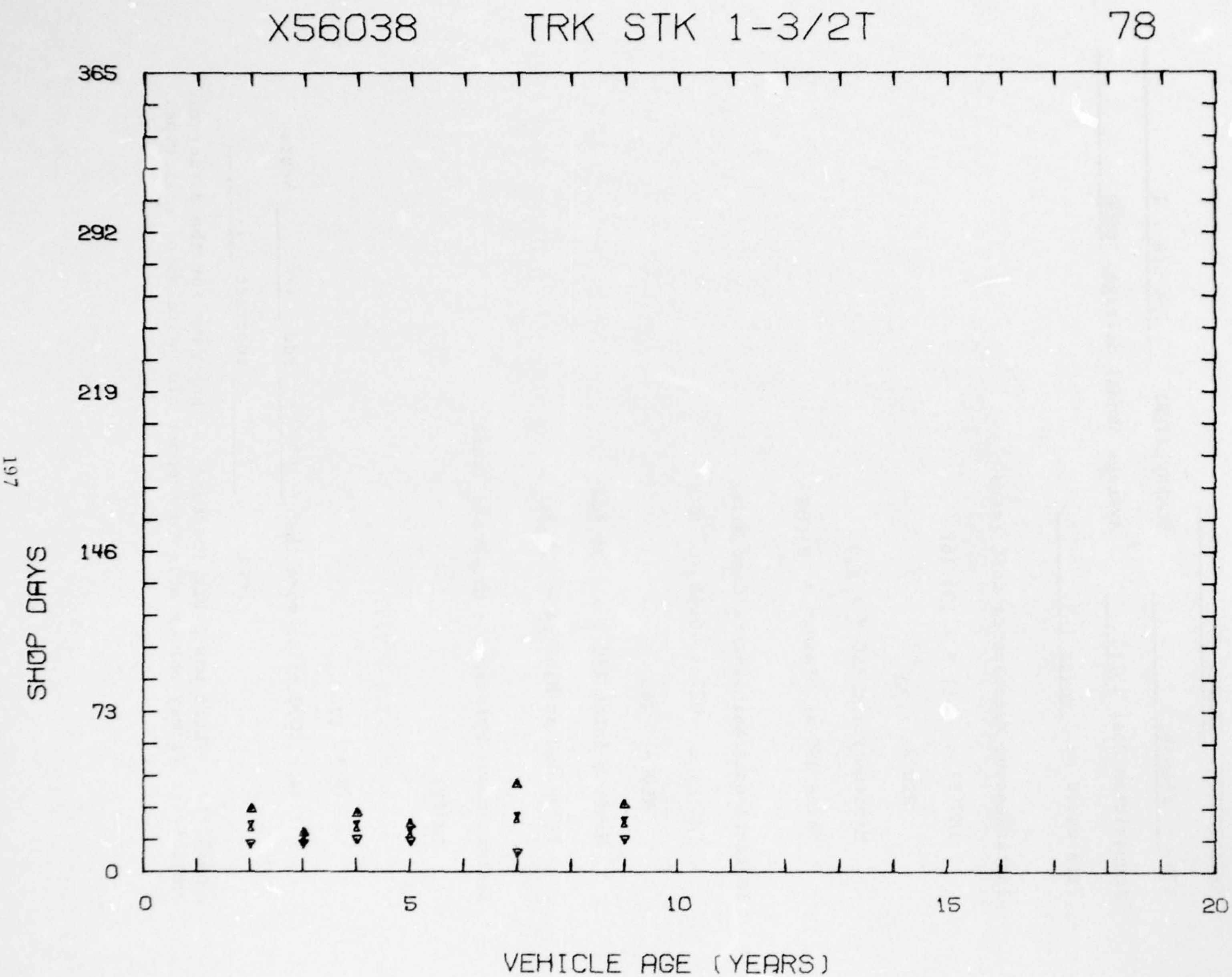

X56038 TRK STK 1-3/2T 78
MILES THIS YEAR
0
5000
10000
15000
20000
25000
0
5
10
15
20
VEHICLE AGE (YEARS)


X56038 TRK STK 1-3/2T 78
ENDING MILEAGE
125000
100000
75000
50000
25000
0
VEHICLE AGE (YEARS)
0
5
10
15
20


X56038 TRK STK 1-3/2T 78
COST (DOLLARS X 100)
0
6
12
18
24
30
VEHICLE AGE (YEARS)
0
5
10
15
20


X56038 TRK STK 1-3/2T 78
COST (CENTS)
0
6
12
18
24
30
0
5
10
15
20
MILEAGE (MILES X 10,000)


X56038
TRK STK 1-3/2T
78
125
100
75
50
25
0
MANHOURS
0
5
10
15
20
VEHICLE AGE (YEARS)


X56038 TRK STK 1-3/2T 78
365
292
219
146
73
0
SHOP DAYS
0
5
10
15
20
VEHICLE AGE (YEARS)

AD-A073 399 ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY ABERDEEN PROV--ETC F/G 13/6

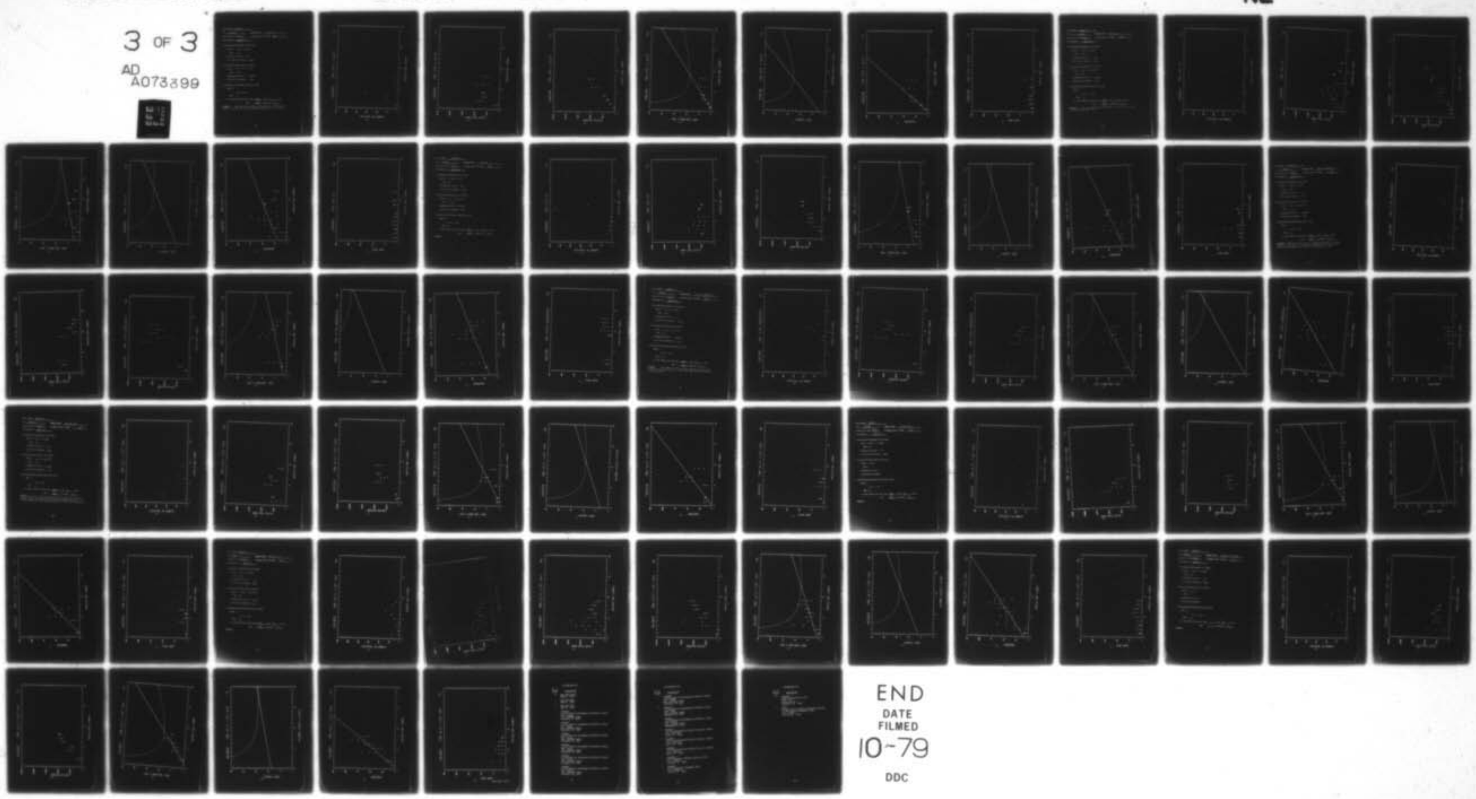
ECONOMIC LIVES OF ADMINISTRATIVE USE VEHICLES.(U)

AUG 79 J J STREILEIN

UNCLASSIFIED AMSAA-TR-278 NL

3 OF 3

AD A073399

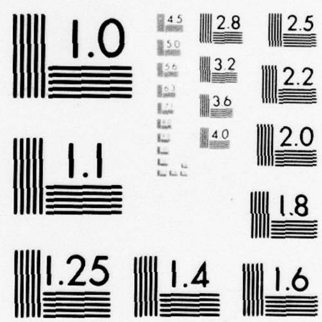


END

DATE FILMED

10-79

DDC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

DATA SOURCE TRADOC 77

LIN X56038 NOMENCLATURE Trk Stk 1 T

Acquisition Cost $5214 Average Annual Mileage 6600

Fits based on years 1-7

Instantaneous Maintenance Cost Years

IMC(Y) = $-81.5 + 131.16Y$

RSD = 270

Minimum Point ASC Y = 8.9

Value ASC at Minimum = $1088

Instantaneous Maintenance Cost Miles

IMC(M) = $.027 + 16.44 \cdot 10^{-7} M$

RSD = 268

Minimum Point ASC Y = 79,644

Value ASC at Minimum = 15.8¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

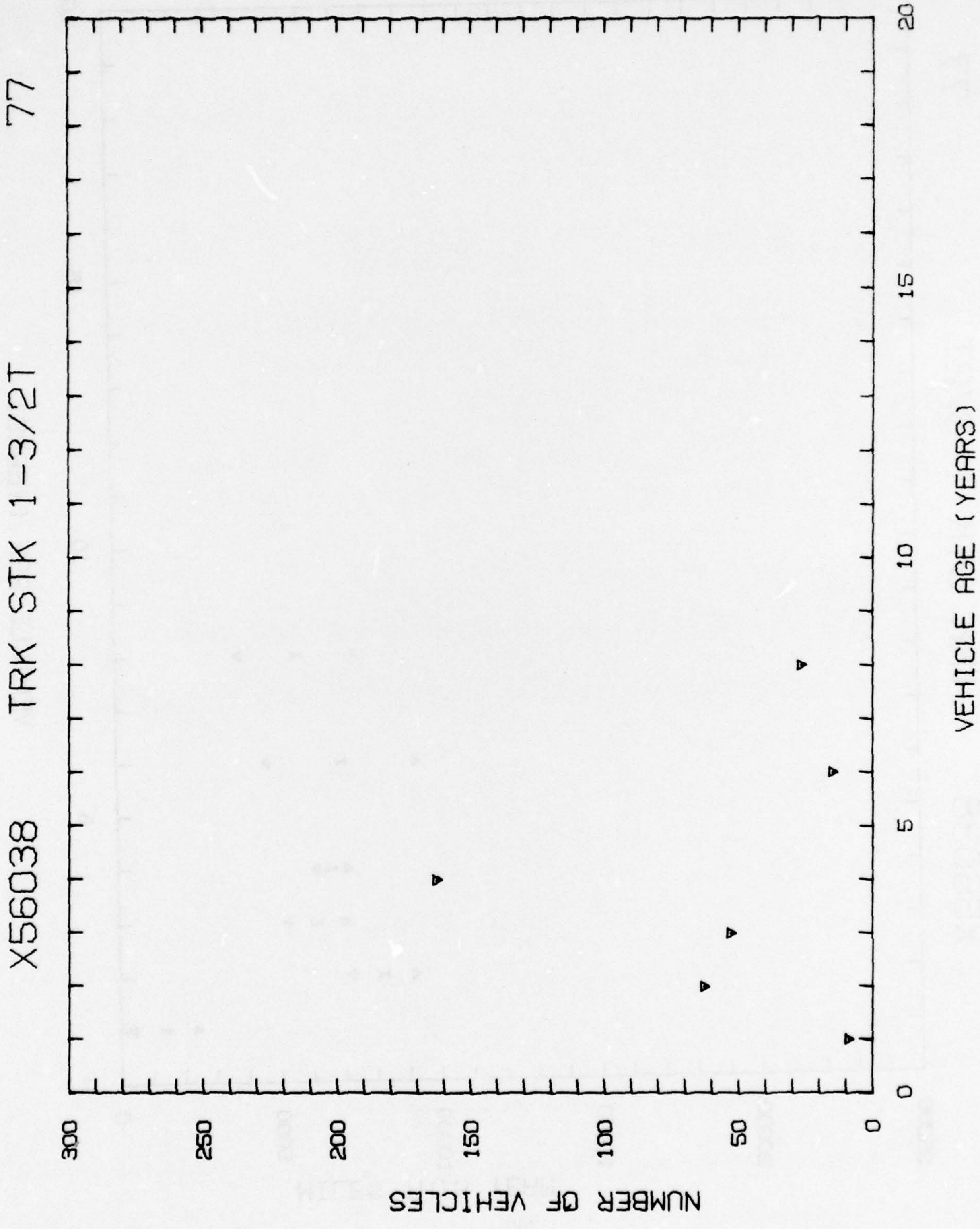
= $-3.6 + 9.49Y$

RSD = 17

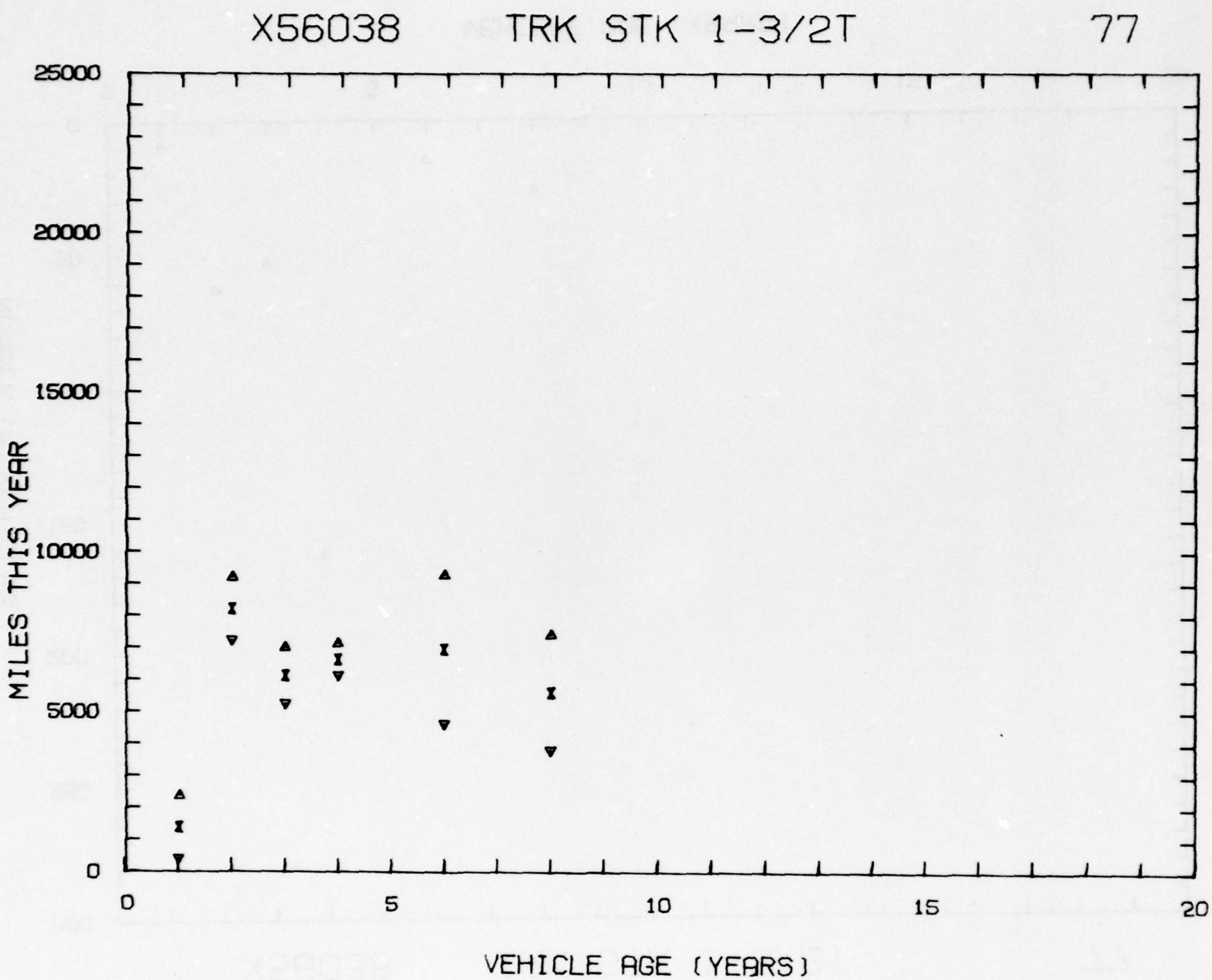
for each 1000 miles more than 6600 add 1.2 hours

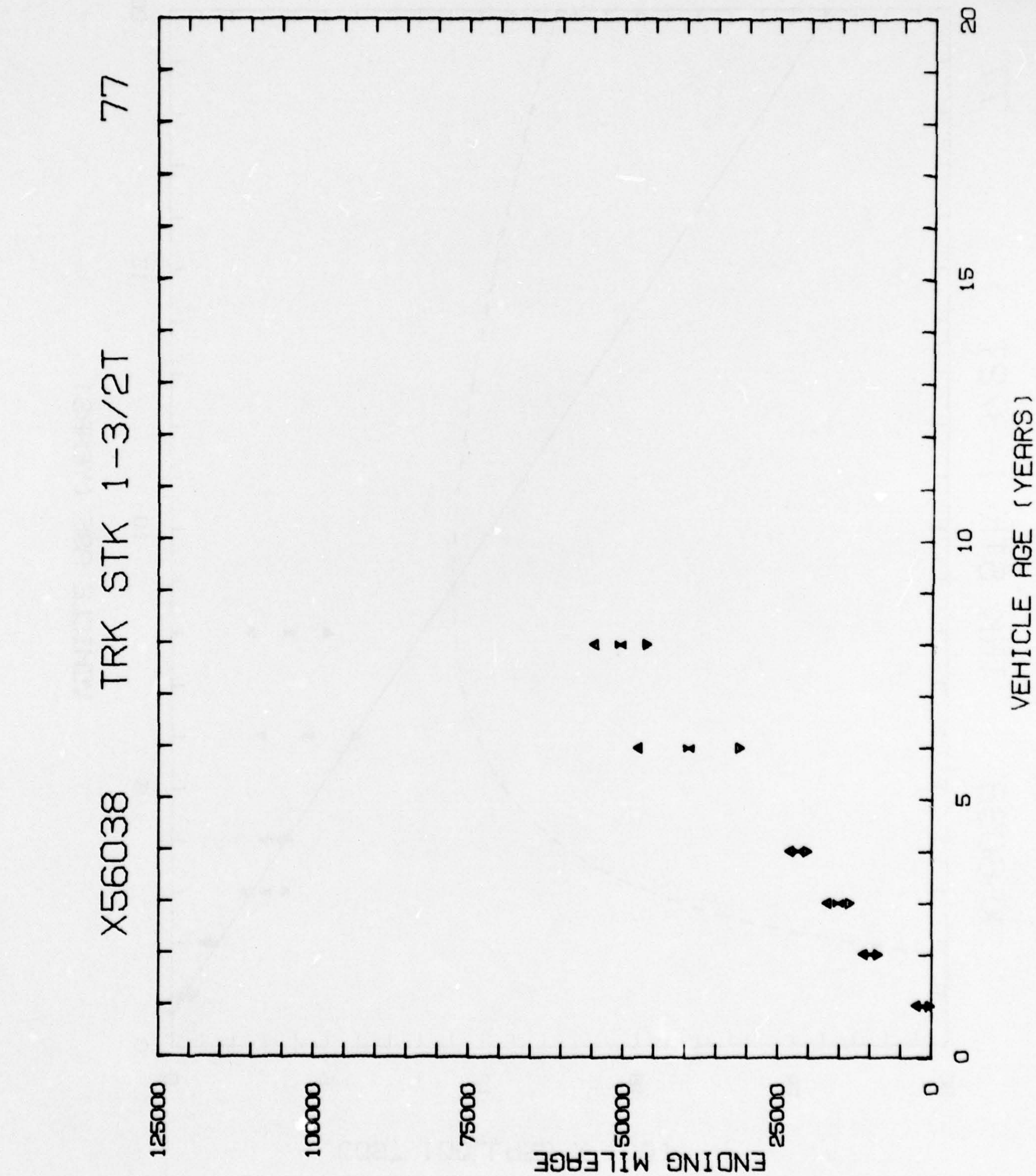
less 6600 subtract 1.2

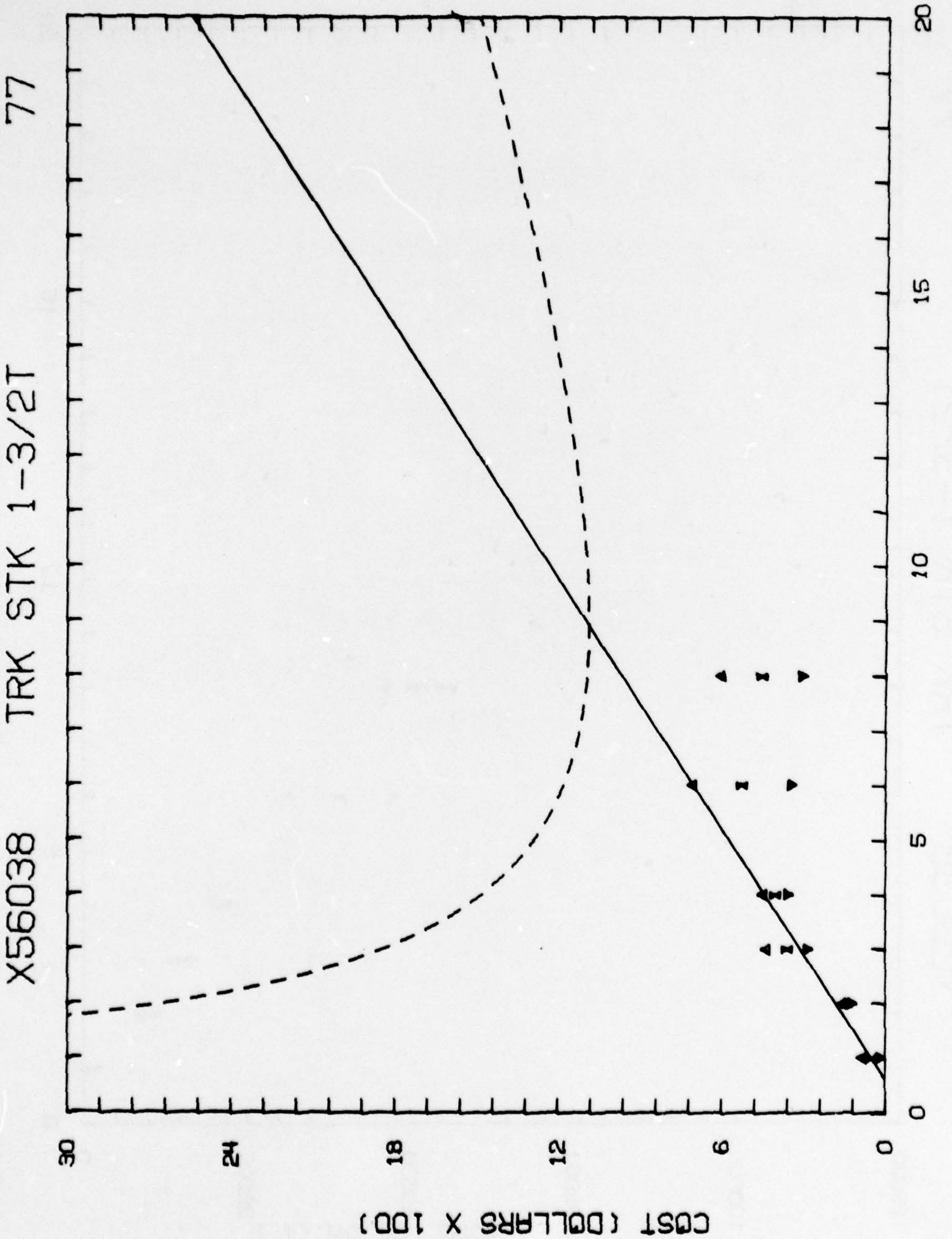
COMMENTS: There was a big increase in shop days for the 8 year old vehicles. We may not be able to support old vehicles of this type.



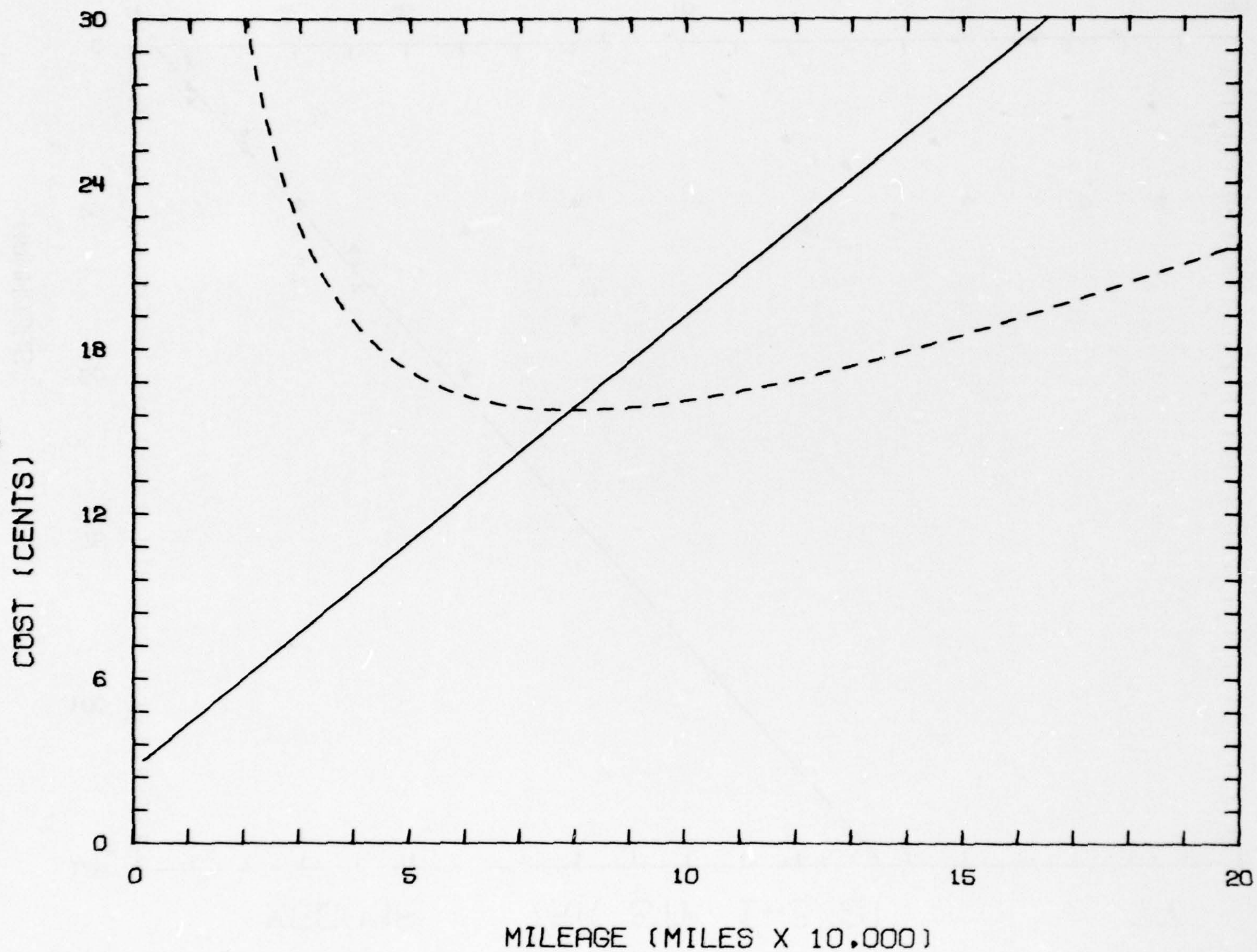
X56038 TRK STK 1-3/2T 77
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20


X56038
TRK STK 1-3/2T
77
MILES THIS YEAR
0
5000
10000
15000
20000
25000
VEHICLE AGE (YEARS)
0
5
10
15
20

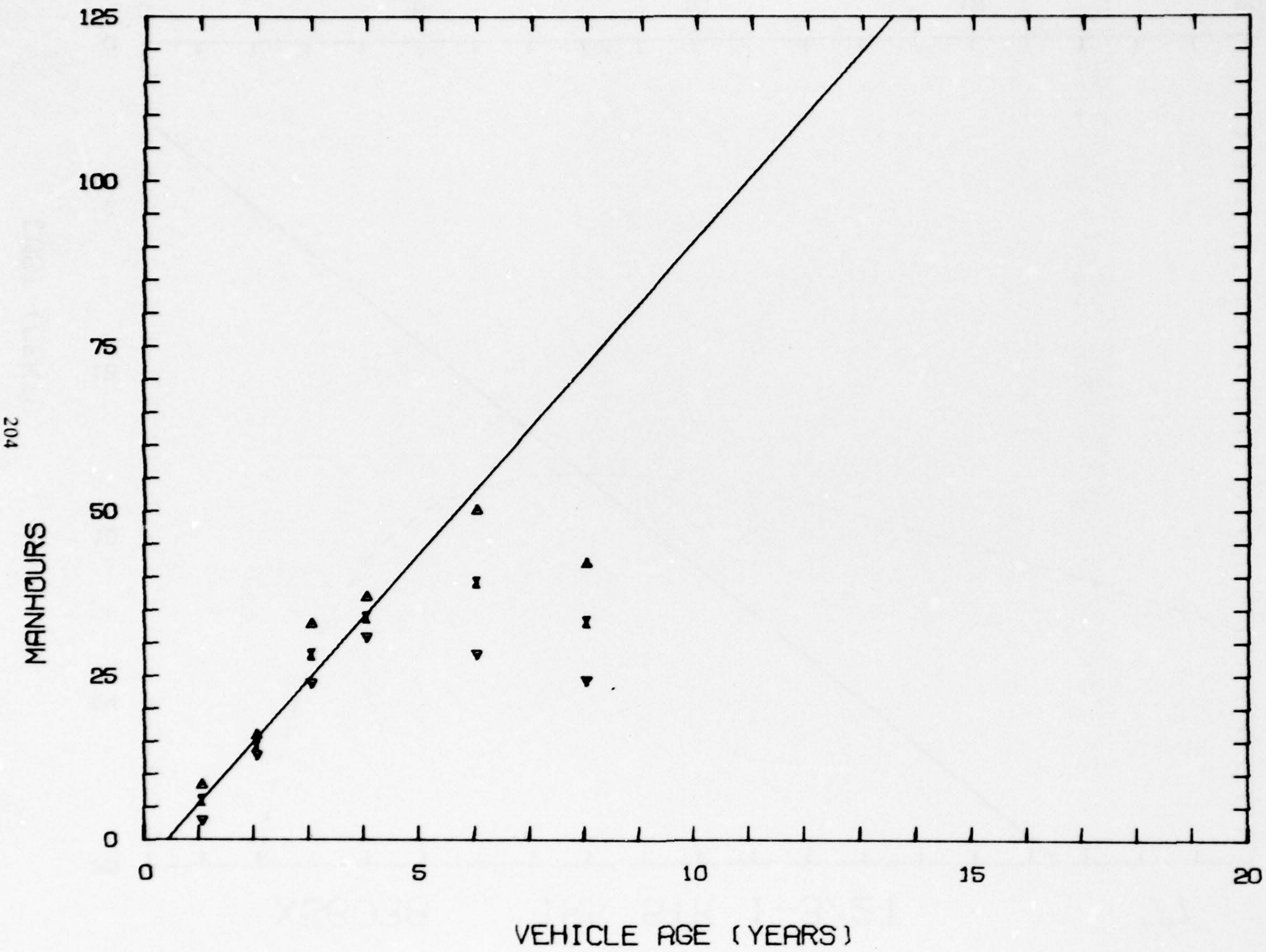

X56038 TRK STK 1-3/2T 77
ENDING MILEAGE
125000
100000
75000
50000
25000
0
VEHICLE AGE (YEARS)
0
5
10
15
20

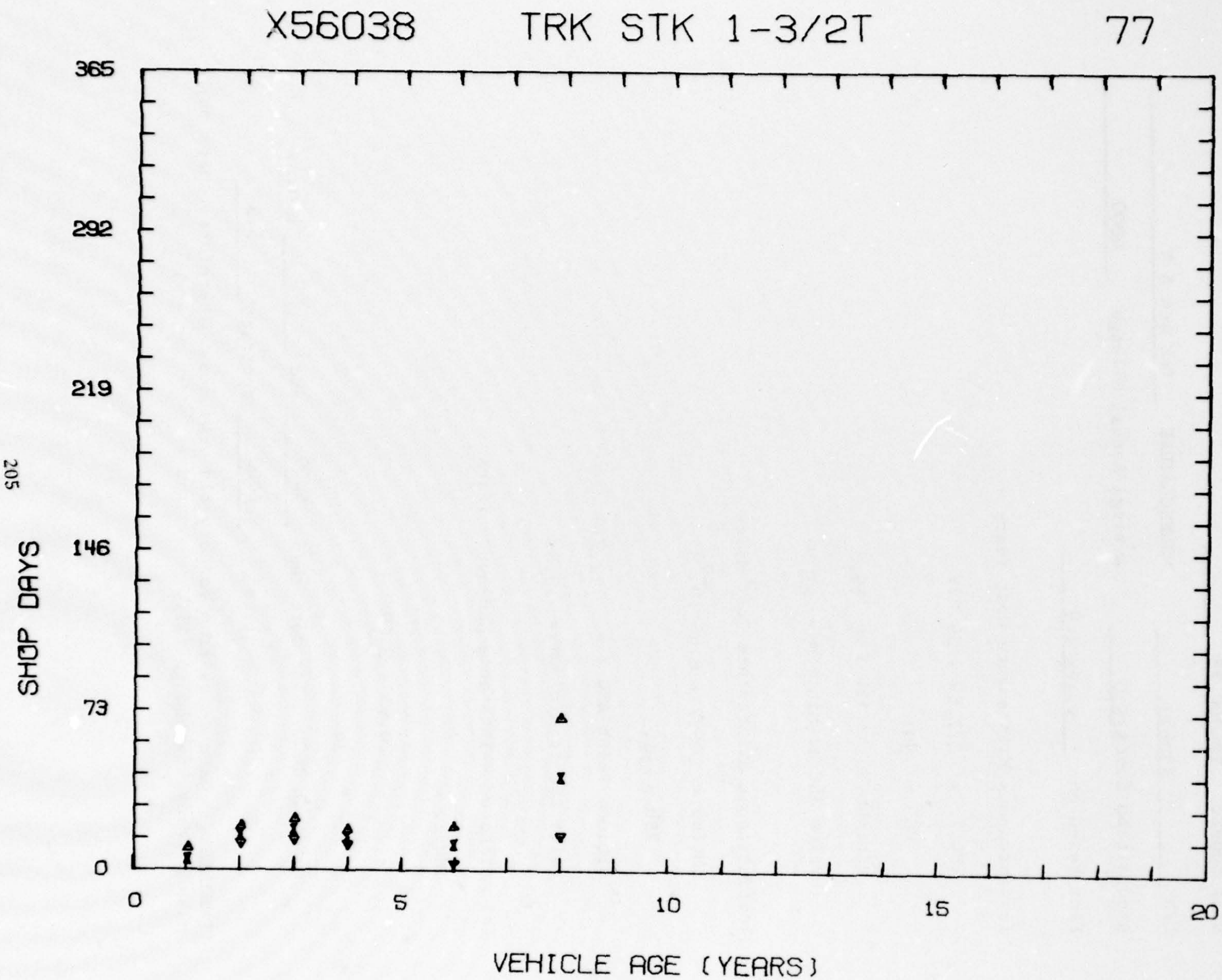

X56038 TRK STK 1-3/2T 77
COST (DOLLARS X 100)
0
6
12
18
24
30
VEHICLE AGE (YEARS)
0
5
10
15
20

X56038 TRK STK 1-3/2T 77



X56038 TRK STK 1-3/2T 77




X56038
TRK STK 1-3/2T
77
SHOP DAYS
365
292
219
146
73
0
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 78

LIN X56483 NOMENCLATURE Trk Stk 5 T

Acquisition Cost $7650 Average Annual Mileage 6000

Fits based on years 1-9

Instantaneous Maintenance Cost Years

$IMC(Y) = 277.69 + 39.02Y$

RSD = 391

Minimum Point ASC Y = 19.8

Value ASC at Minimum = $1050

Instantaneous Maintenance Cost Miles

$IMC(M) = .0622 + 8.66 \cdot 10^{-7}M$

RSD = 393

Minimum Point ASC Y = 132,919

Value ASC at Minimum = 18.8¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

$= 20.95 + 3.09Y$

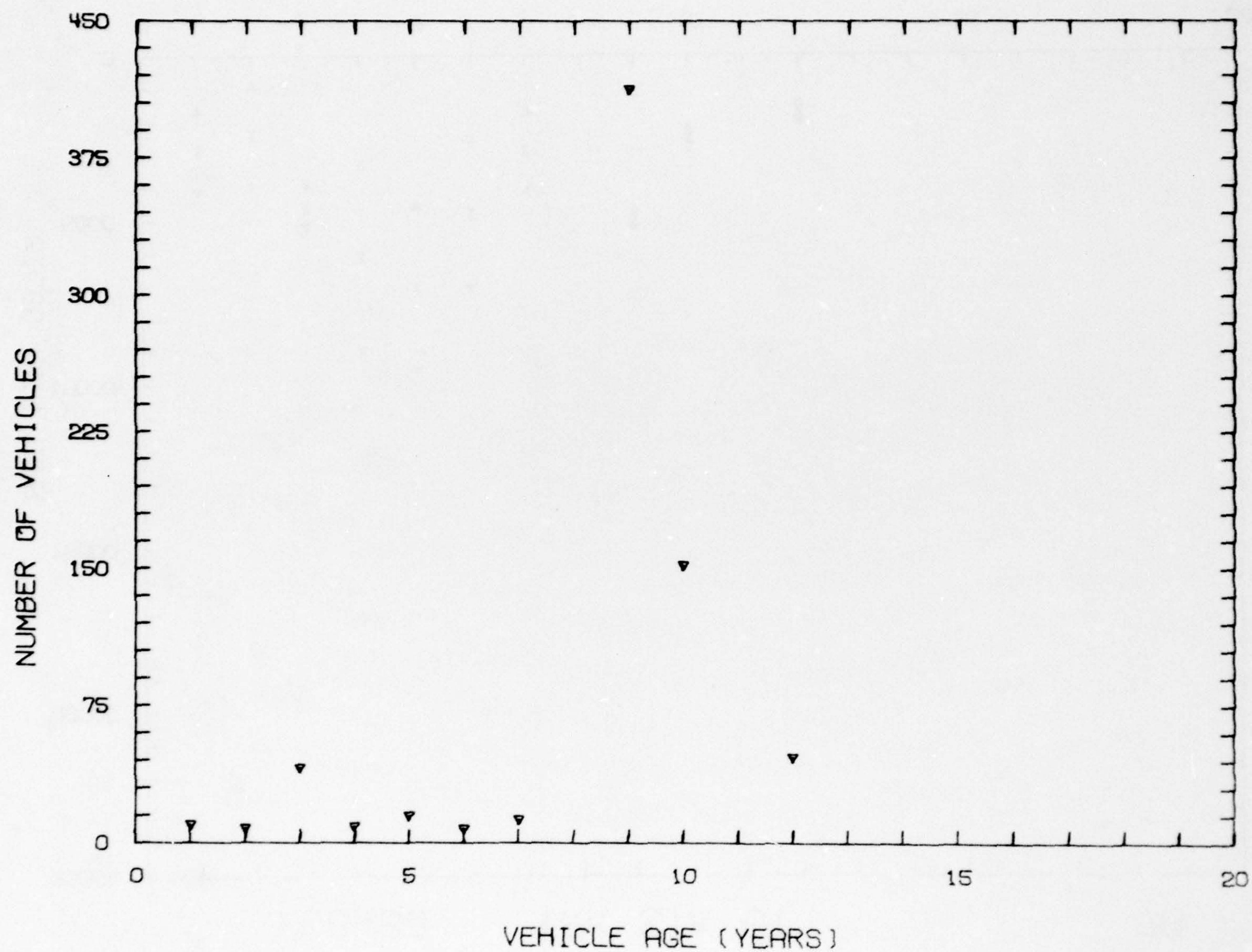
RSD = 24

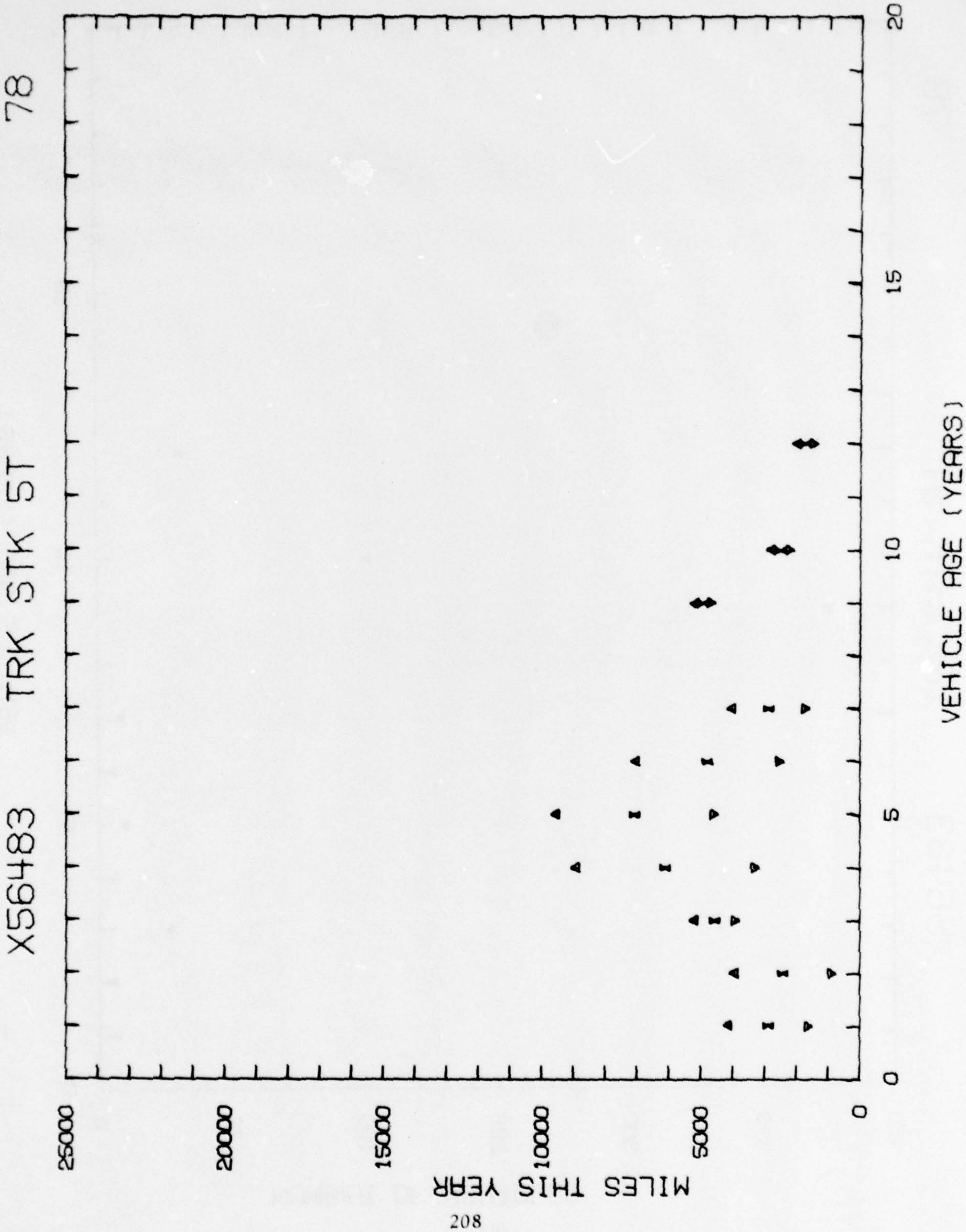
for each 1000 miles more than 6000 add 3.3 hours

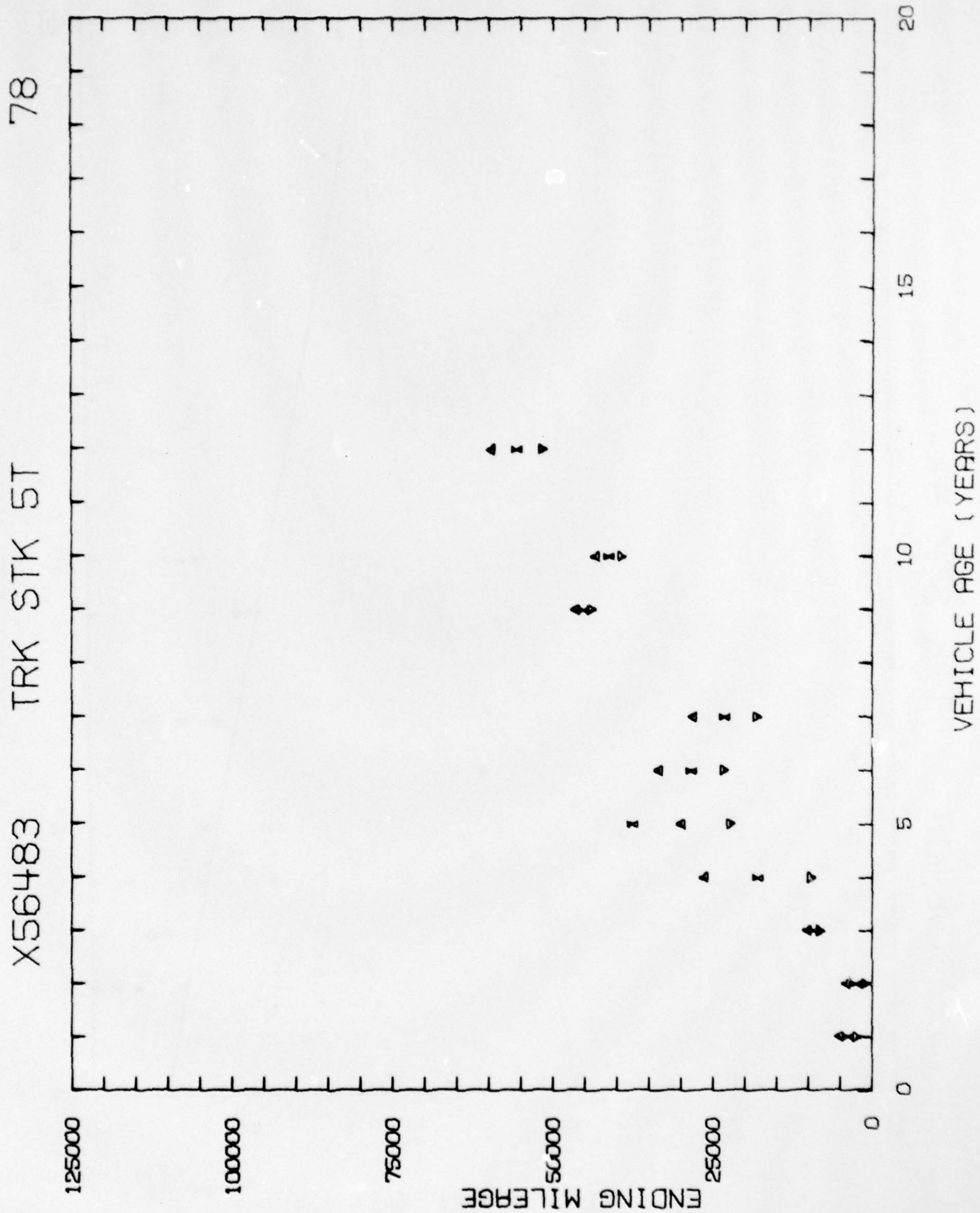
less 6000 subtract 3.3

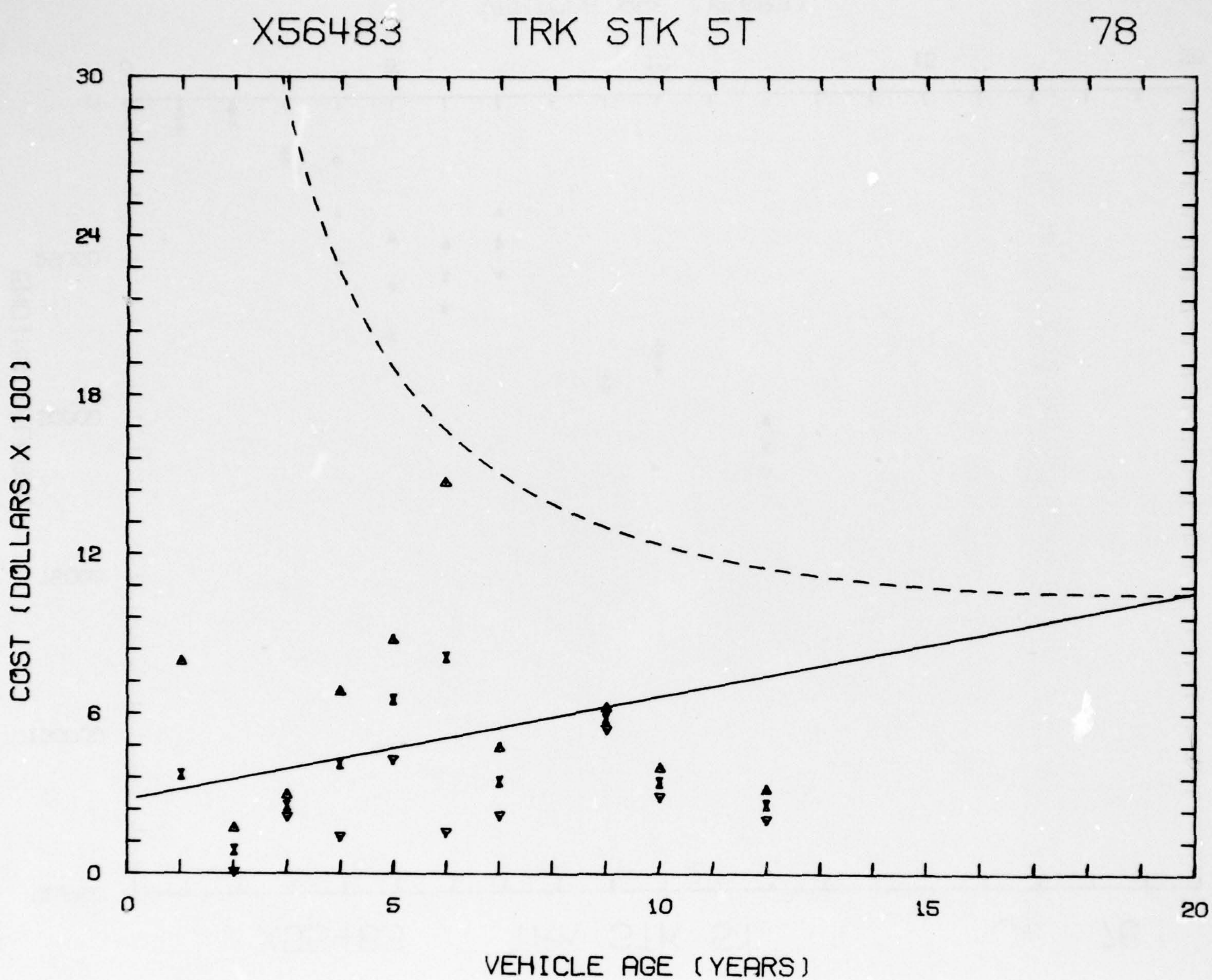
COMMENTS: Data comes from largely old vehicles. Therefore, costs may have already started to fall.

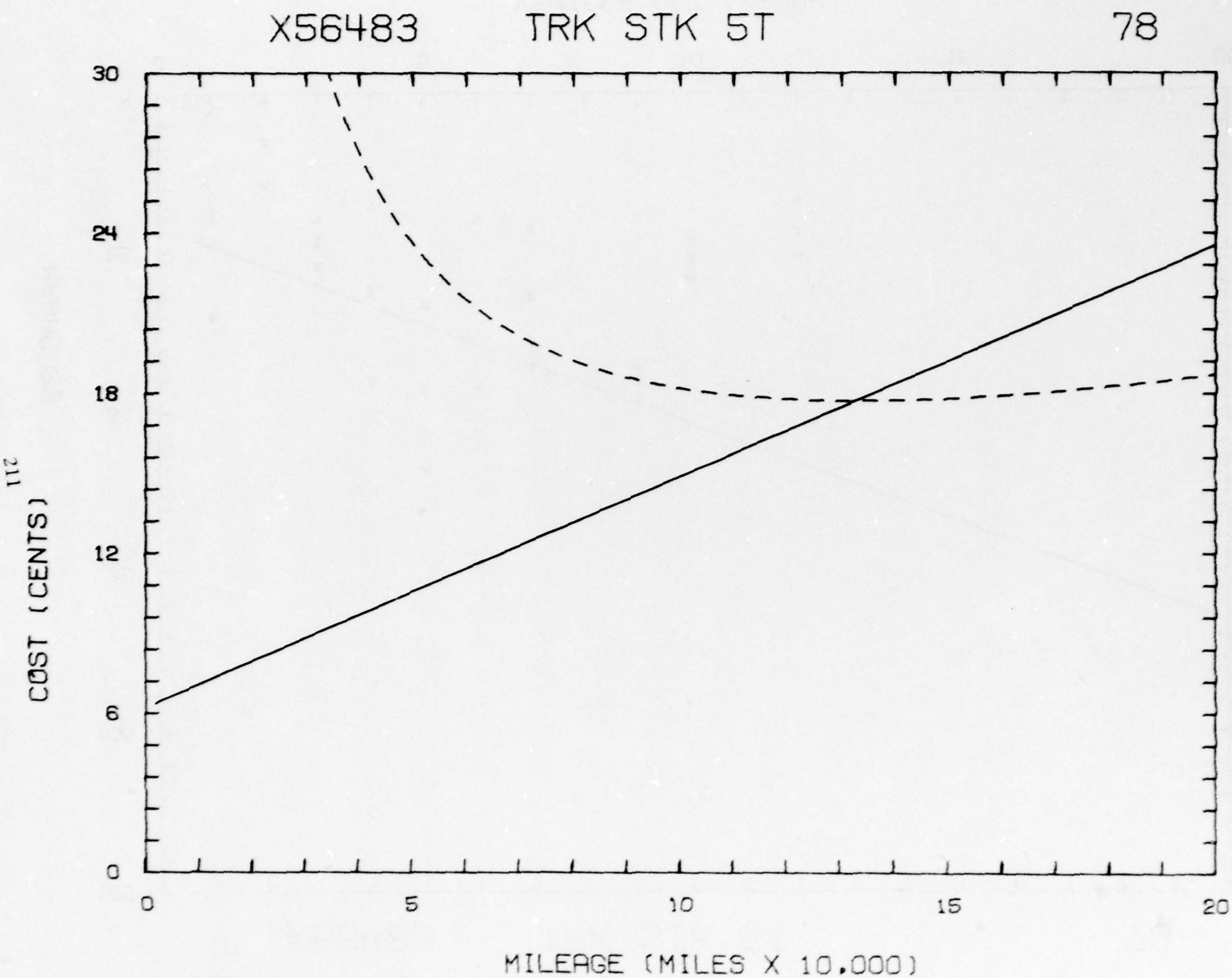
X56483 TRK STK 5T 78

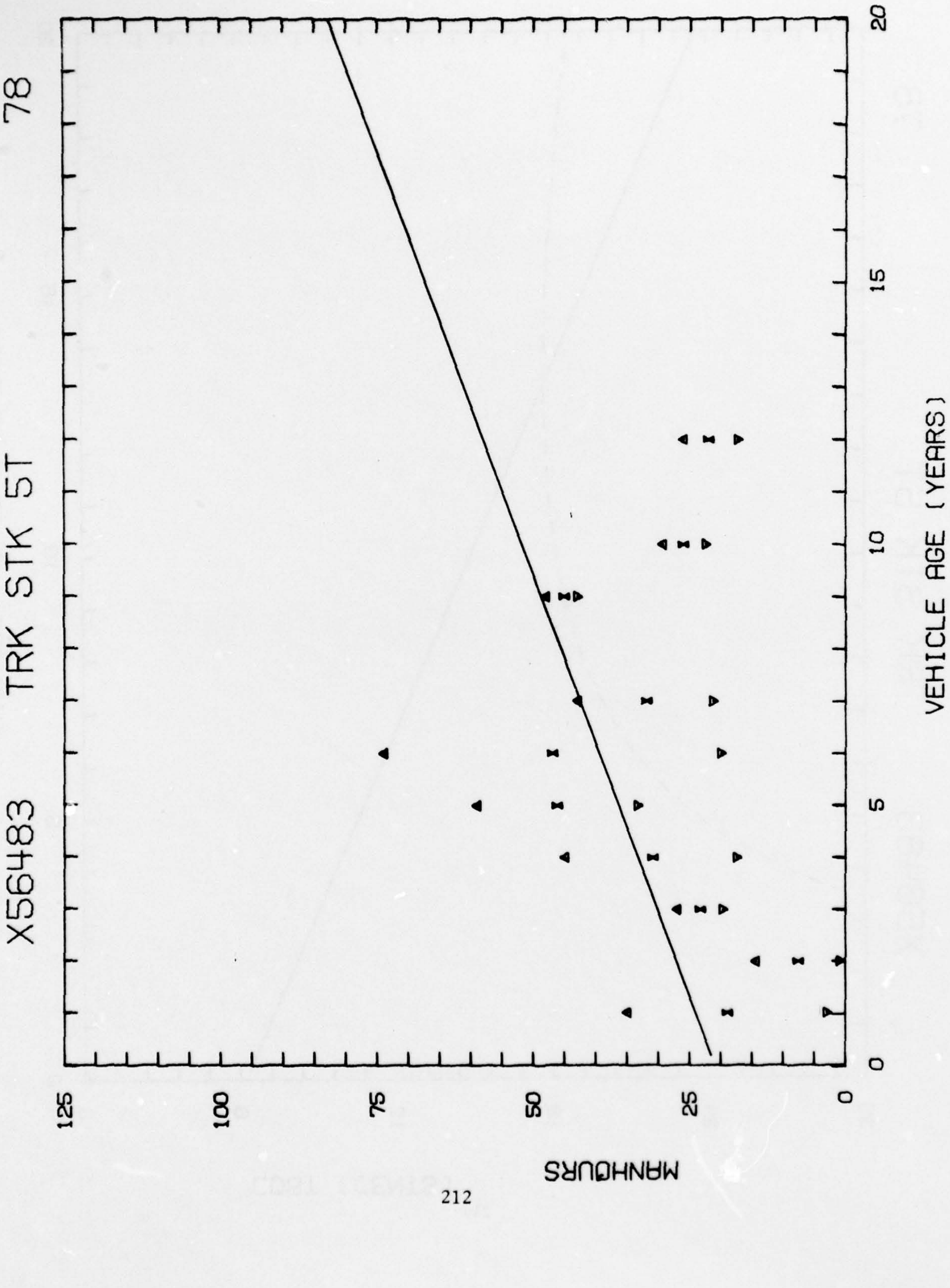


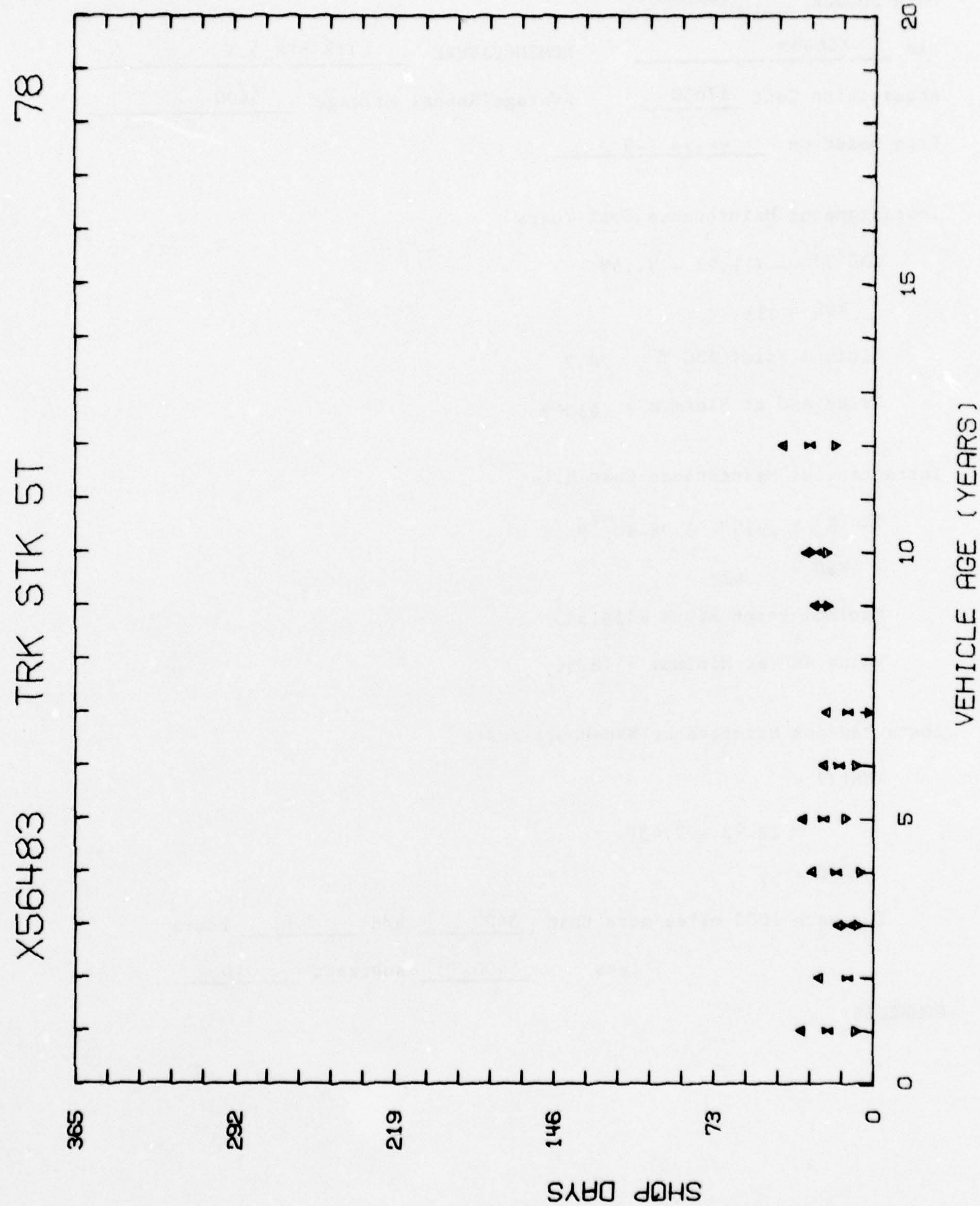

X56483 TRK STK 5T 78
MILES THIS YEAR
0
5000
10000
15000
20000
25000
0
5
10
15
20
VEHICLE AGE (YEARS)


X56483 TRK STK 5T 78
ENDING MILEAGE
125000
100000
75000
50000
25000
0
VEHICLE AGE (YEARS)
0
5
10
15
20


X56483 TRK STK 5T 78
COST (DOLLARS X 100)
30
24
18
12
6
0
5
10
15
20
VEHICLE AGE (YEARS)


X56483 TRK STK 5T 78
30
24
18
12
6
0
0
5
10
15
20
COST (CENTS)
MILEAGE (MILES X 10,000)


X56483 TRK STK 5T 78
MANHOURS
0
25
50
75
100
125
VEHICLE AGE (YEARS)
0
5
10
15
20


X56483 TRK STK 5T 78
SHOP DAYS
365
292
219
146
73
0
VEHICLE AGE (YEARS)
0
5
10
15
20

DATA SOURCE TRADOC 77

LIN X56483 NOMENCLATURE Trk Stk 5 T

Acquisition Cost $7650 Average Annual Mileage 5400

Fits based on years 1-9

Instantaneous Maintenance Cost Years

$IMC(Y) = 311.83 + 37.5Y$

RSD = 431

Minimum Point ASC Y = 20.2

Value ASC at Minimum = $1069

Instantaneous Maintenance Cost Miles

$IMC(M) = .915 + 6.08 \cdot 10^{-7} M$

RSD = 433

Minimum Point ASC Y = 158,633

Value ASC at Minimum = 18.8¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) =$

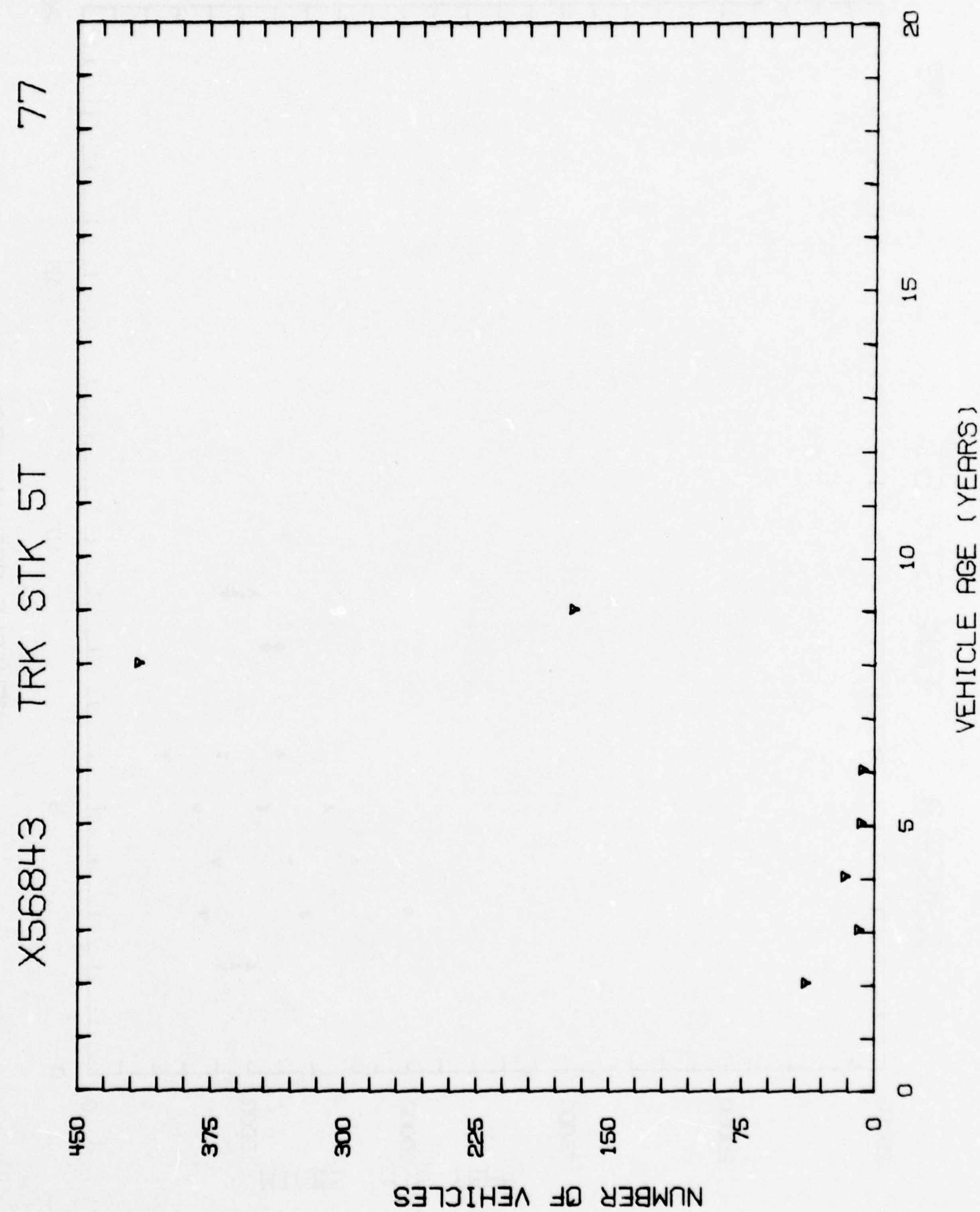
$= 20.92 + 3.45Y$

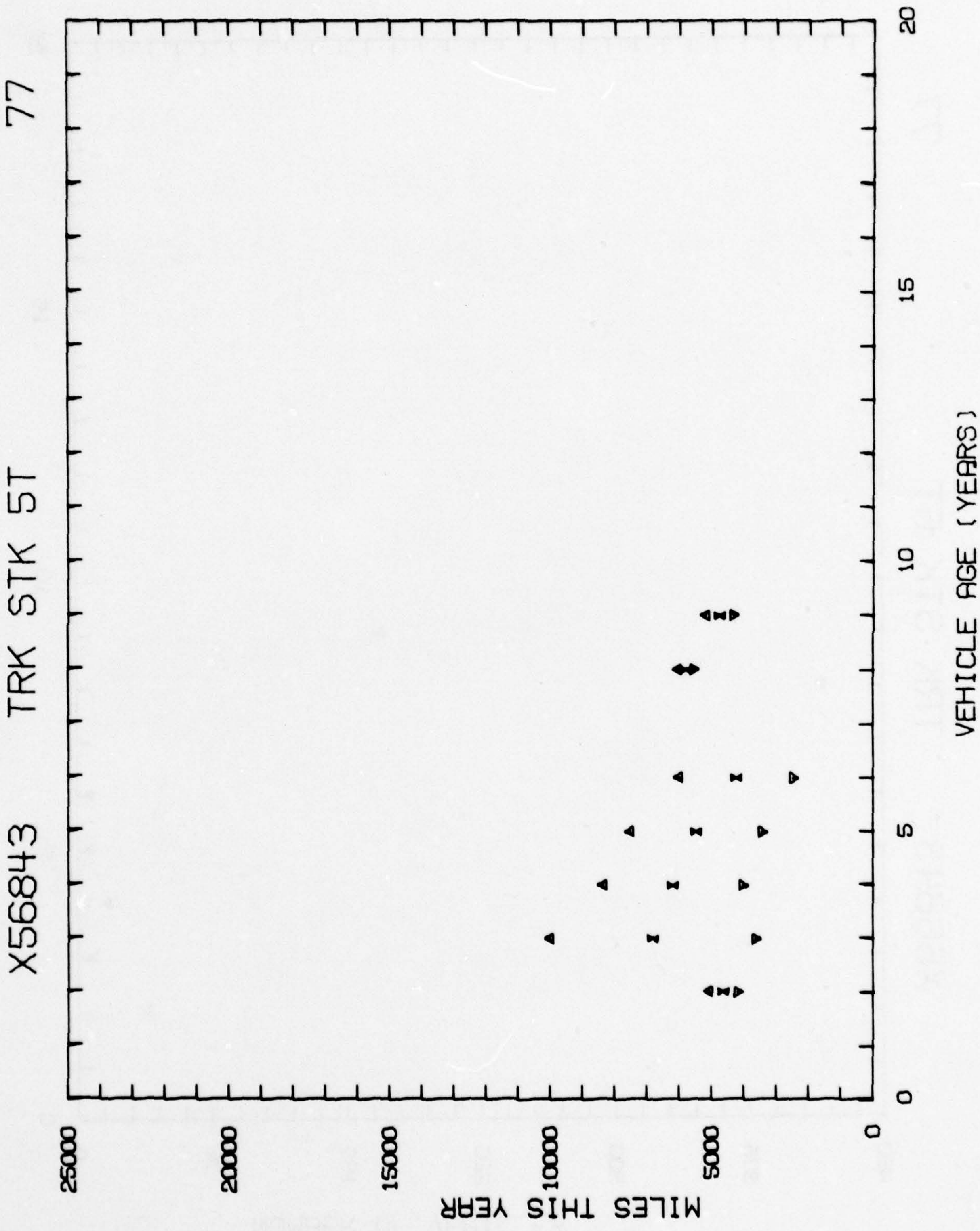
RSD = 27

for each 1000 miles more than 5400 add 3.6 hours

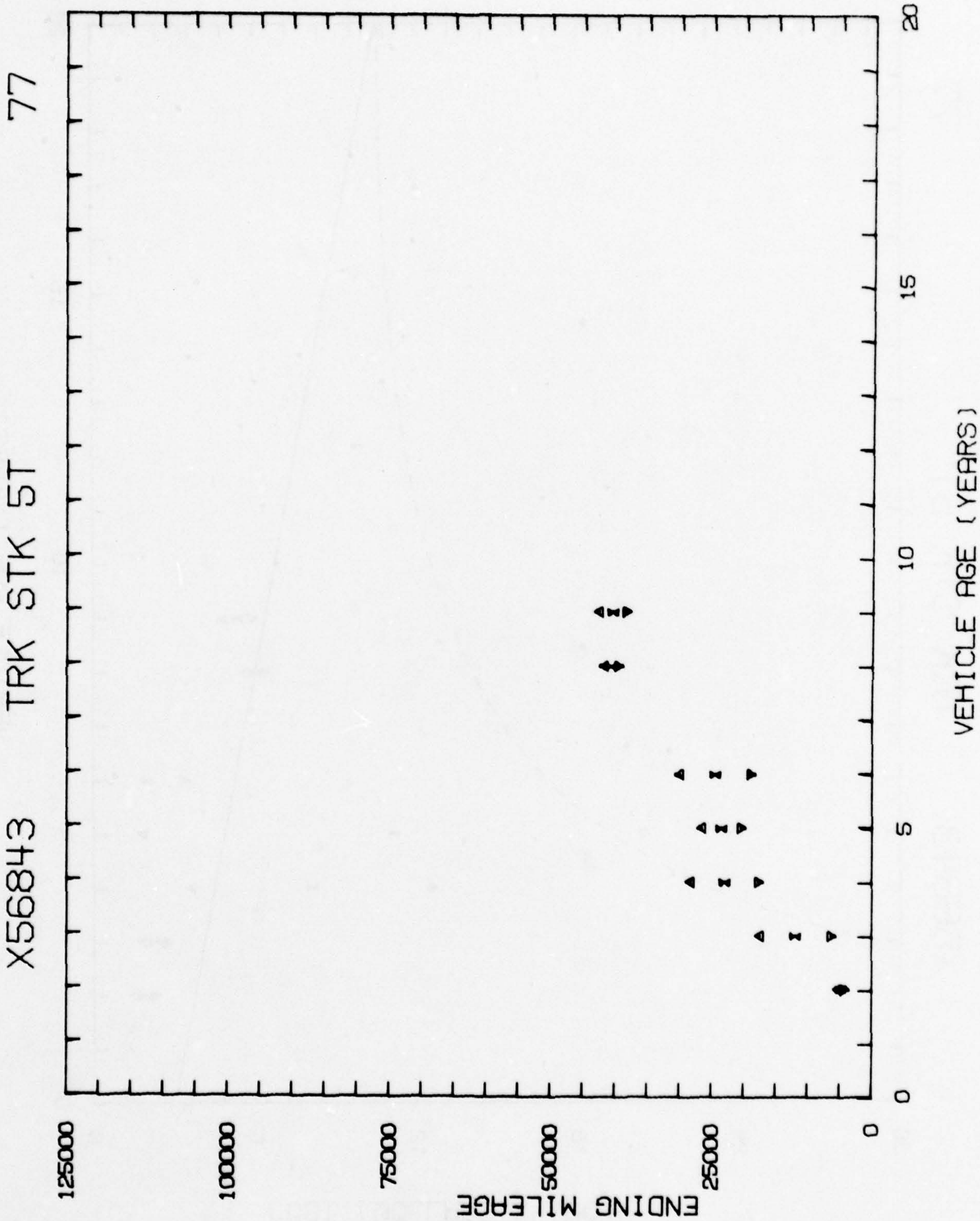
less 5400 subtract 3.6

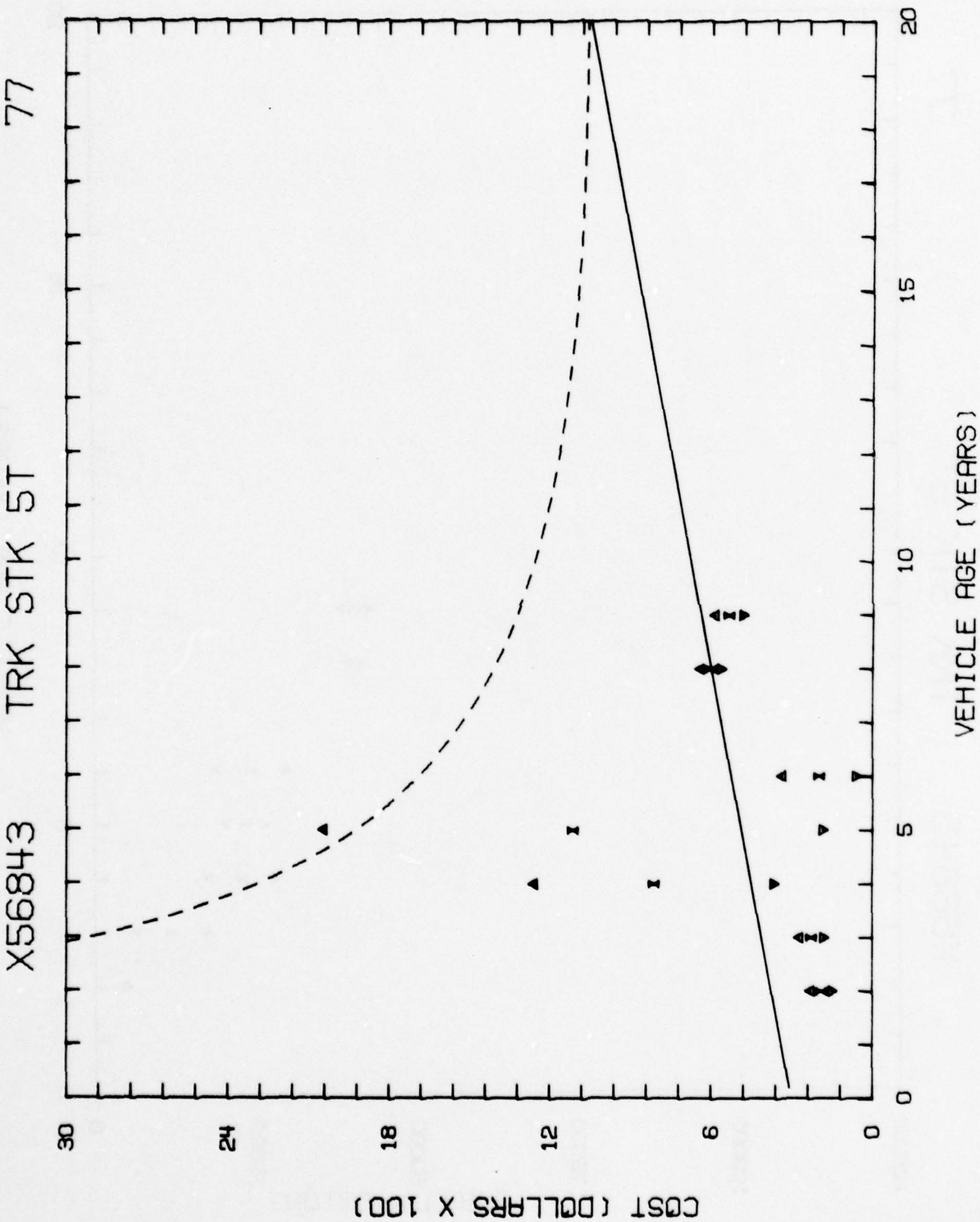
COMMENTS:

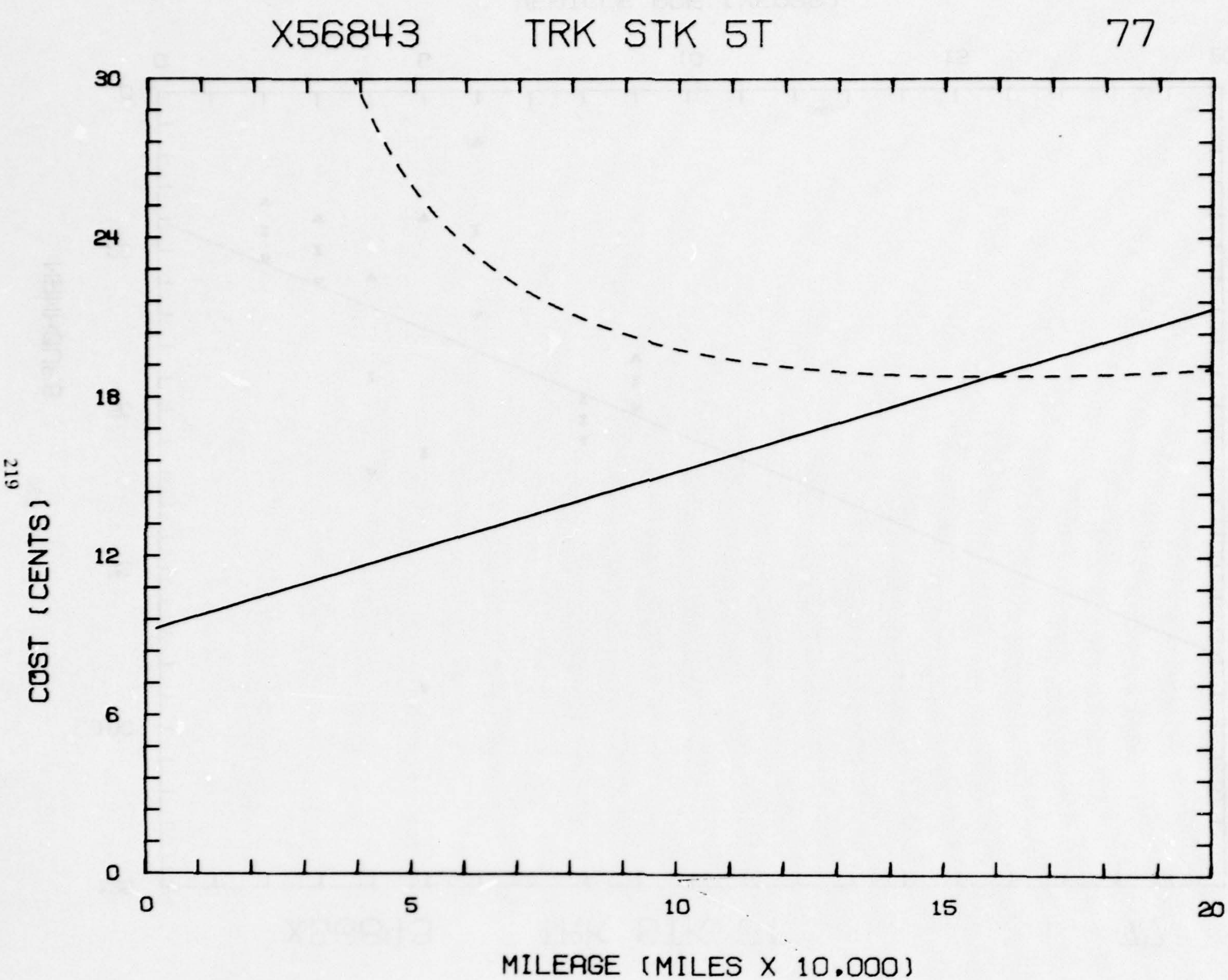

X56843 TRK STK 5T 77
NUMBER OF VEHICLES
0
75
150
225
300
375
450
VEHICLE AGE (YEARS)
0
5
10
15
20

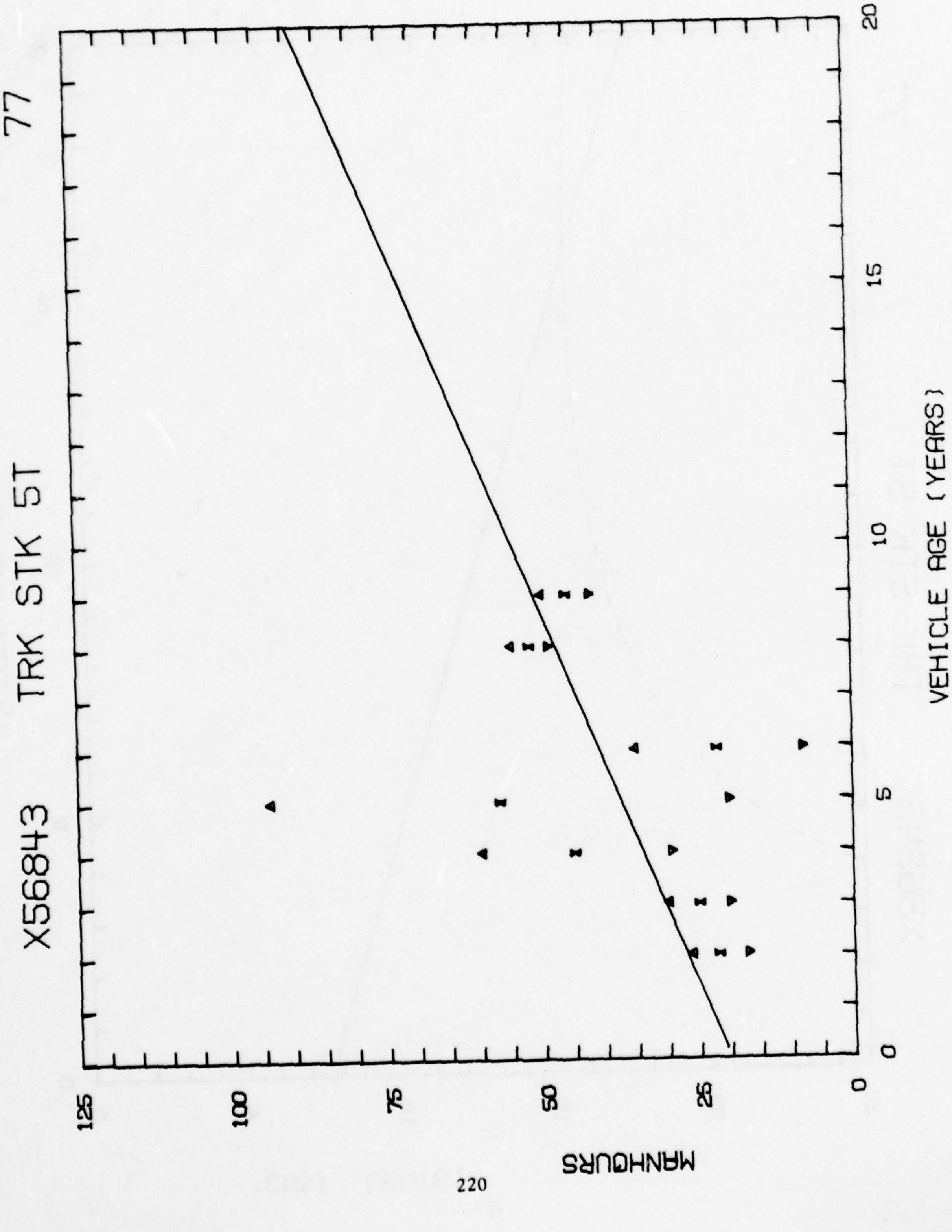


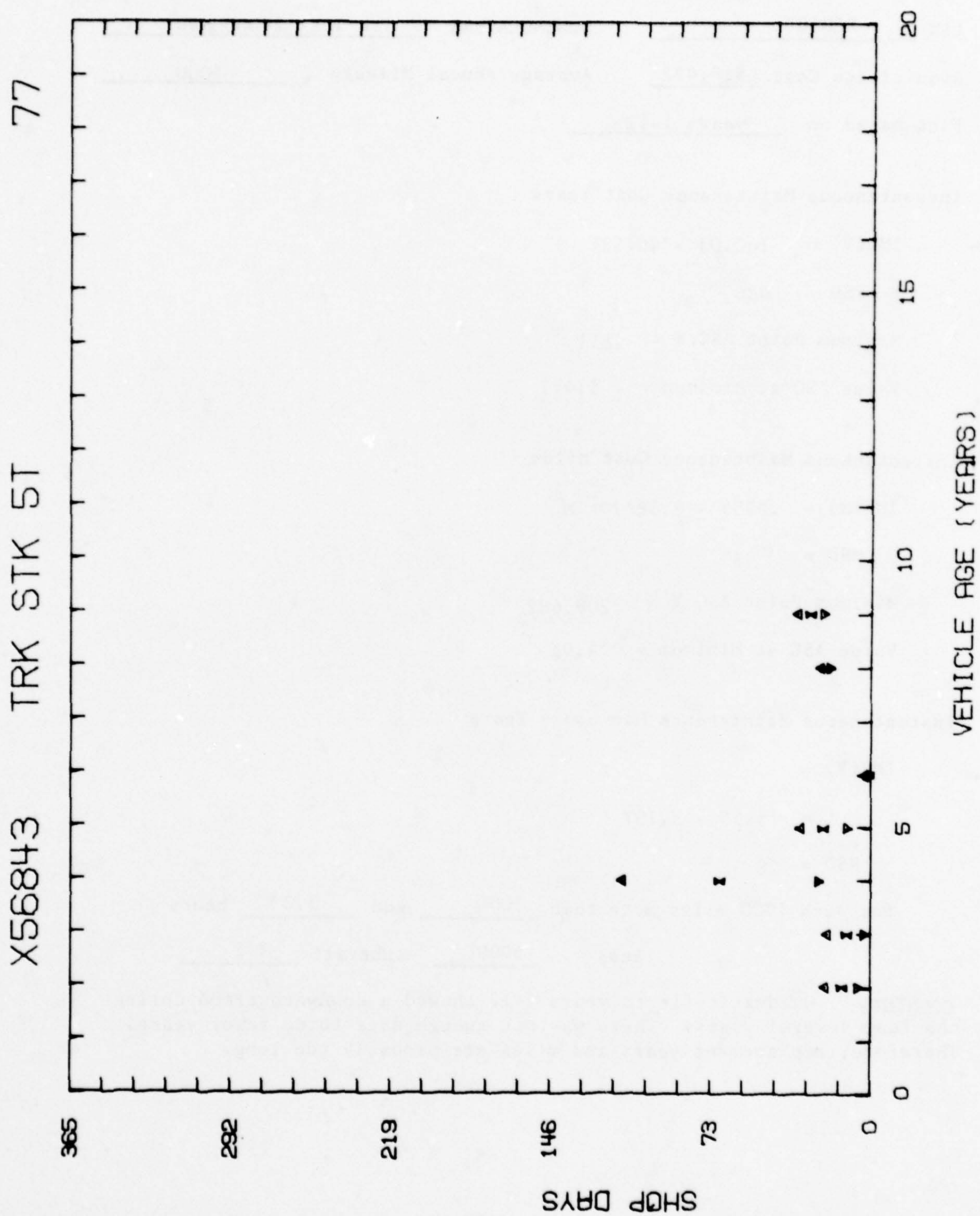
X56843 TRK STK 5T 77
MILES THIS YEAR
0
5000
10000
15000
20000
25000
VEHICLE AGE (YEARS)
0
5
10
15
20


X56843 TRK STK 5T 77
ENDING MILEAGE
125000
100000
75000
50000
25000
0
VEHICLE AGE (YEARS)
0
5
10
15
20


X56843 TRK STK 5T 77
COST (DOLLARS X 100)
0
6
12
18
24
30
VEHICLE AGE (YEARS)
0
5
10
15
20


X56843 TRK STK 5T 77
30
24
18
12
6
0
0
5
10
15
20
COST (CENTS)
MILEAGE (MILES X 10,000)


X56843
TRK STK 5T
77
MANHOURS
0
25
50
75
100
125
VEHICLE AGE (YEARS)
0
5
10
15
20


X56843 TRK STK 5T 77
SHOP DAYS
0
73
146
219
292
365
VEHICLE AGE (YEARS)
0
5
10
15
20

DATA SOURCE TRADOC 78

LIN X60185 NOMENCLATURE Trk Tctr 28000 GVW

Acquisition Cost $18,422 Average Annual Mileage 5000

Fits based on years 1-12

Instantaneous Maintenance Cost Years

$IMC(Y) = 160.03 + 46.62Y$

RSD = 436

Minimum Point ASC Y = 28.1

Value ASC at Minimum = $1471

Instantaneous Maintenance Cost Miles

$IMC(M) = .0733 + 8.38 \cdot 10^{-7} M$

RSD = 435

Minimum Point ASC Y = 209,682

Value ASC at Minimum = 24.9¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) =$

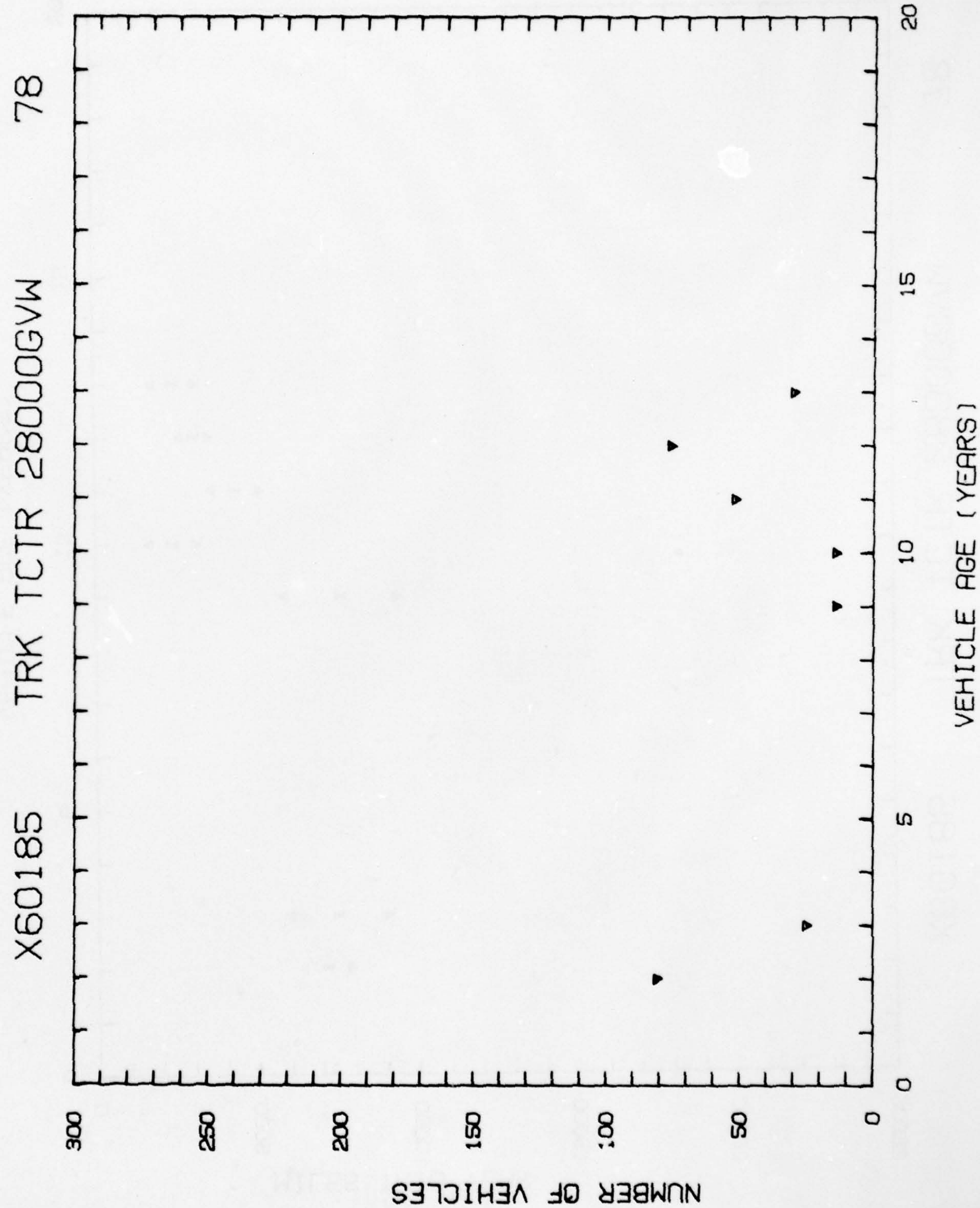
$= 15.35 + 3.19Y$

RSD = 28

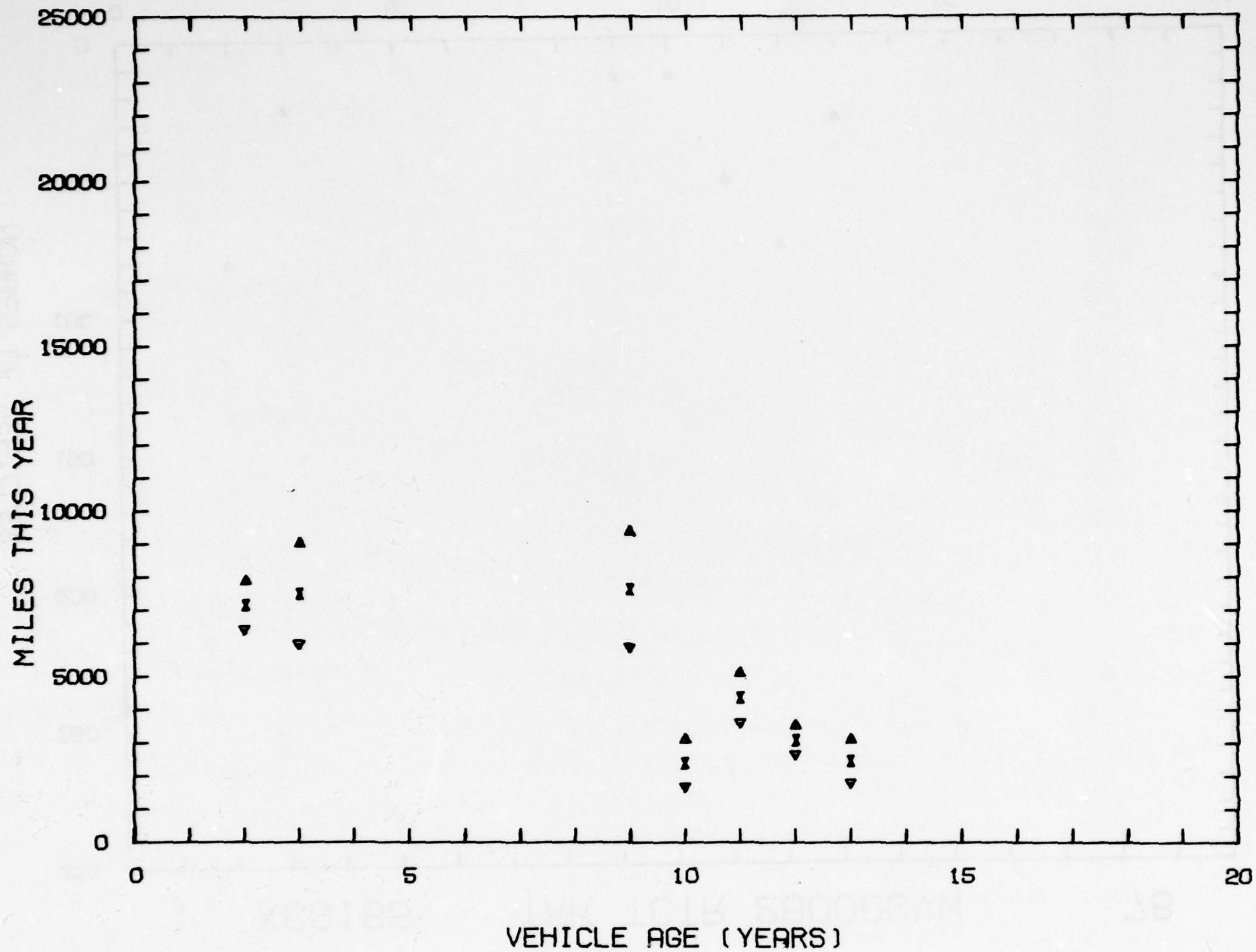
for each 1000 miles more than 5000 add 3.2 hours

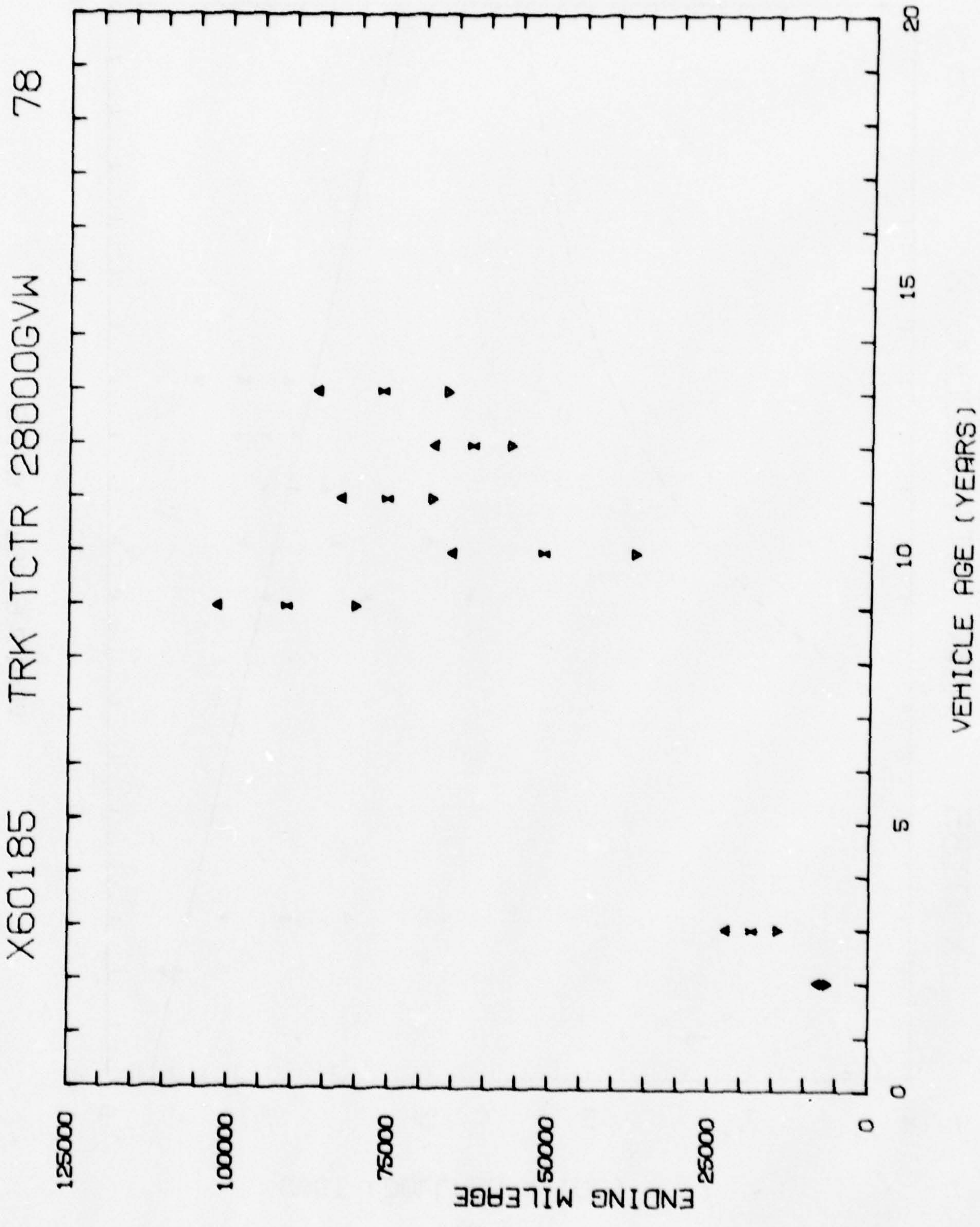
less 5000 subtract 3.2

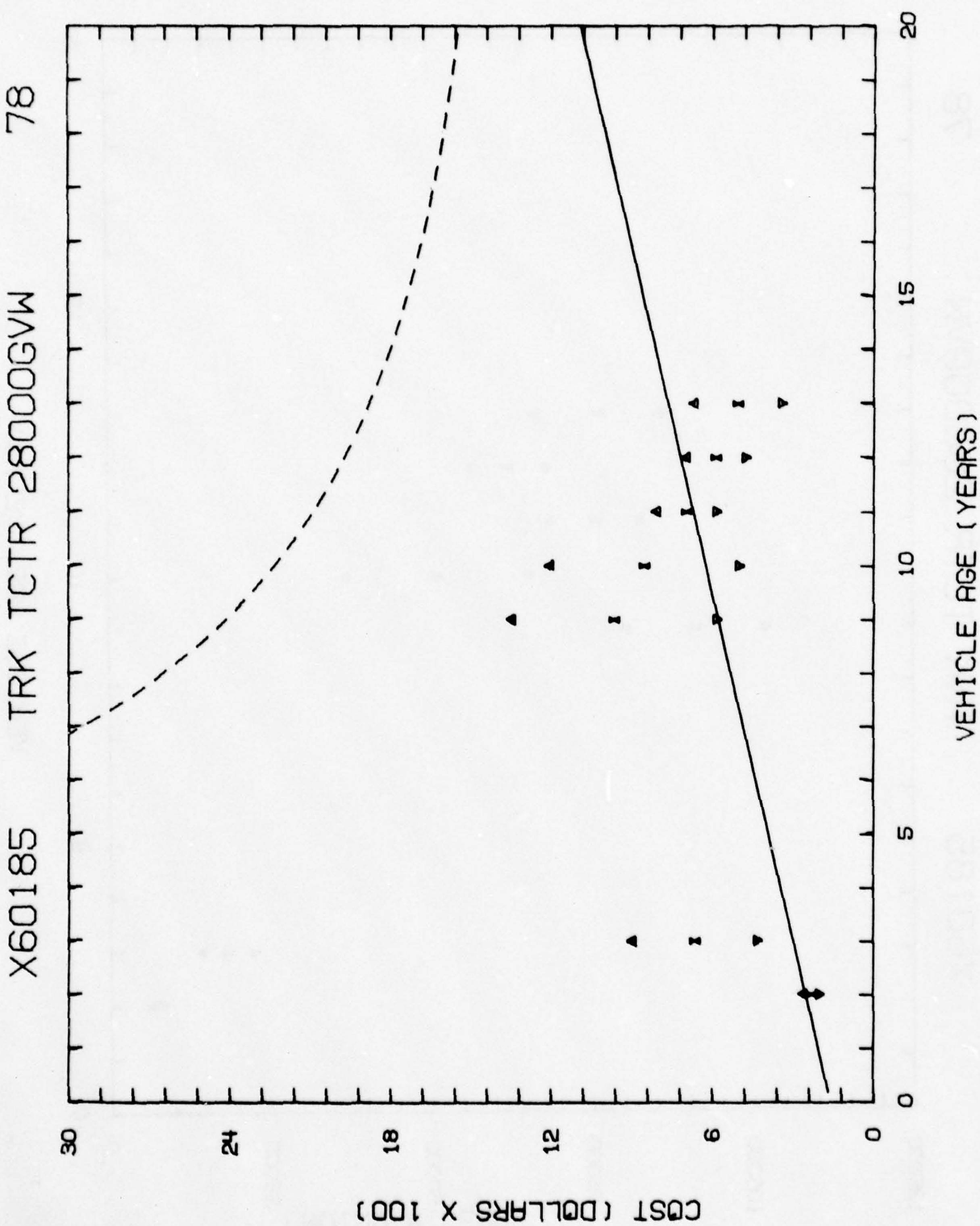
COMMENTS: Quadratic fit to years 1-12 showed a downward trend during the last several years. There was not enough data to do fewer years. Therefore, replacement years and miles are probably too long.

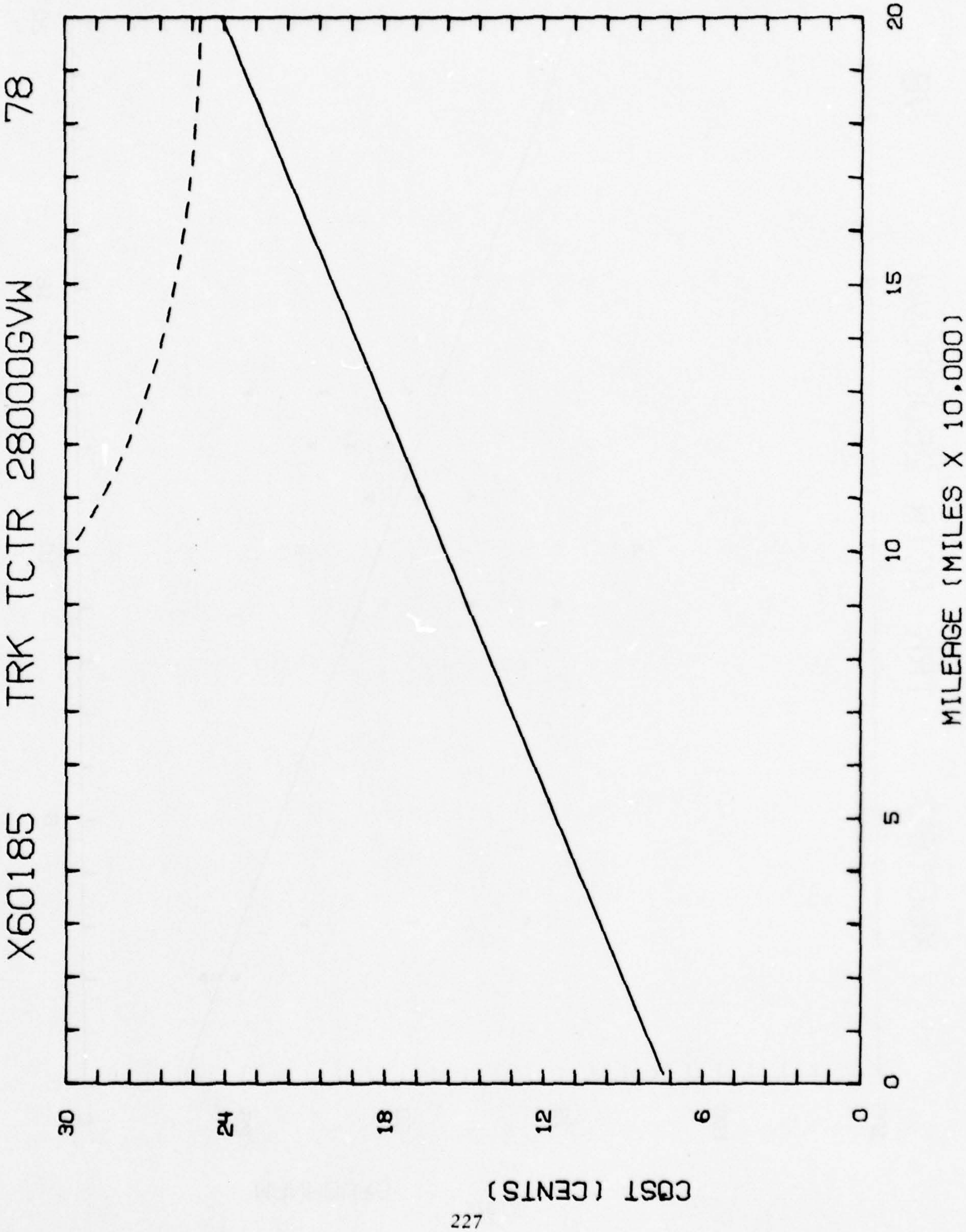

X60185 TRK TCTR 28000GVW 78
NUMBER OF VEHICLES
VEHICLE AGE (YEARS)
0
50
100
150
200
250
300
0
5
10
15
20

X60185 TRK TCTR 28000GVW 78

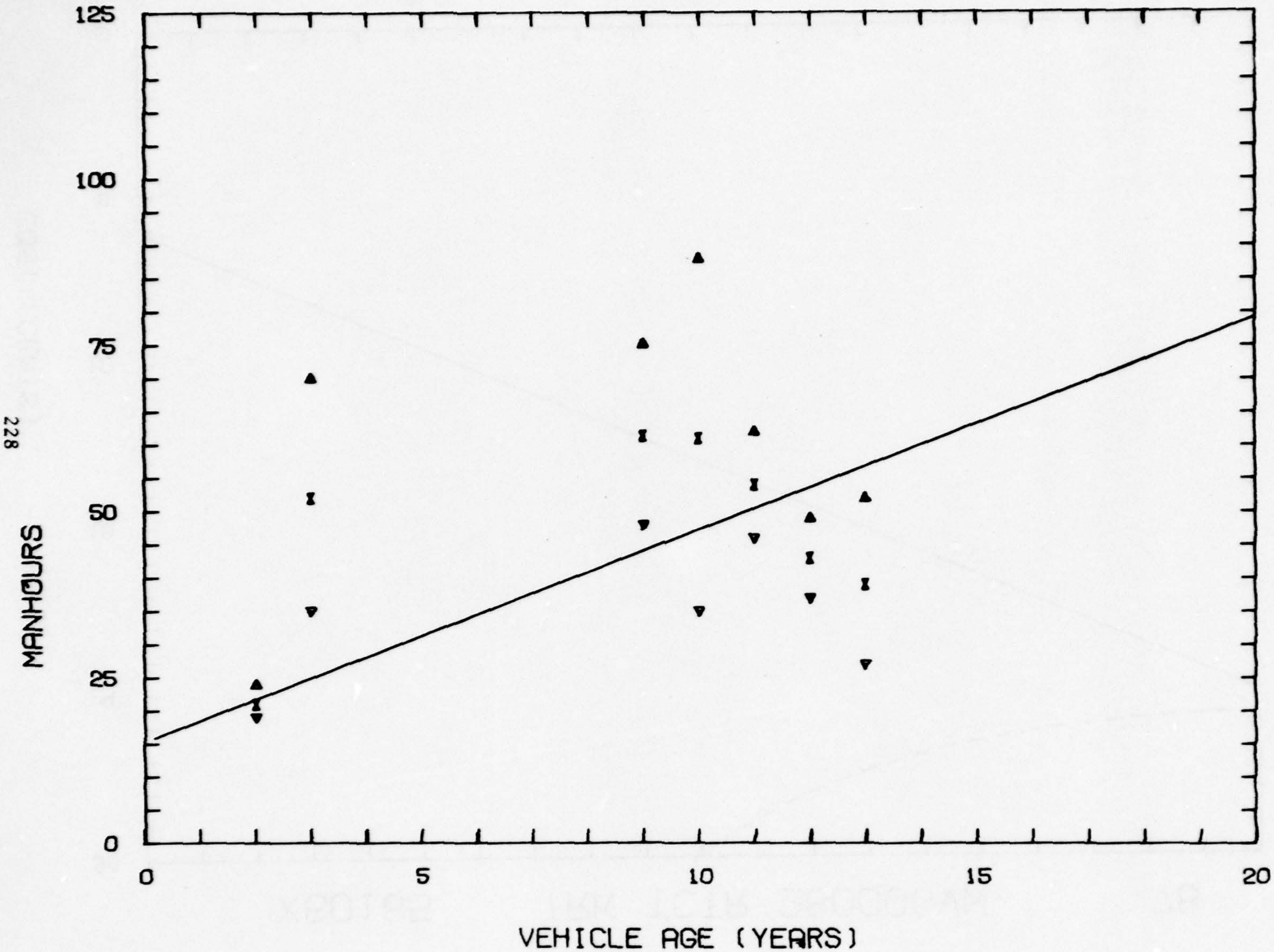


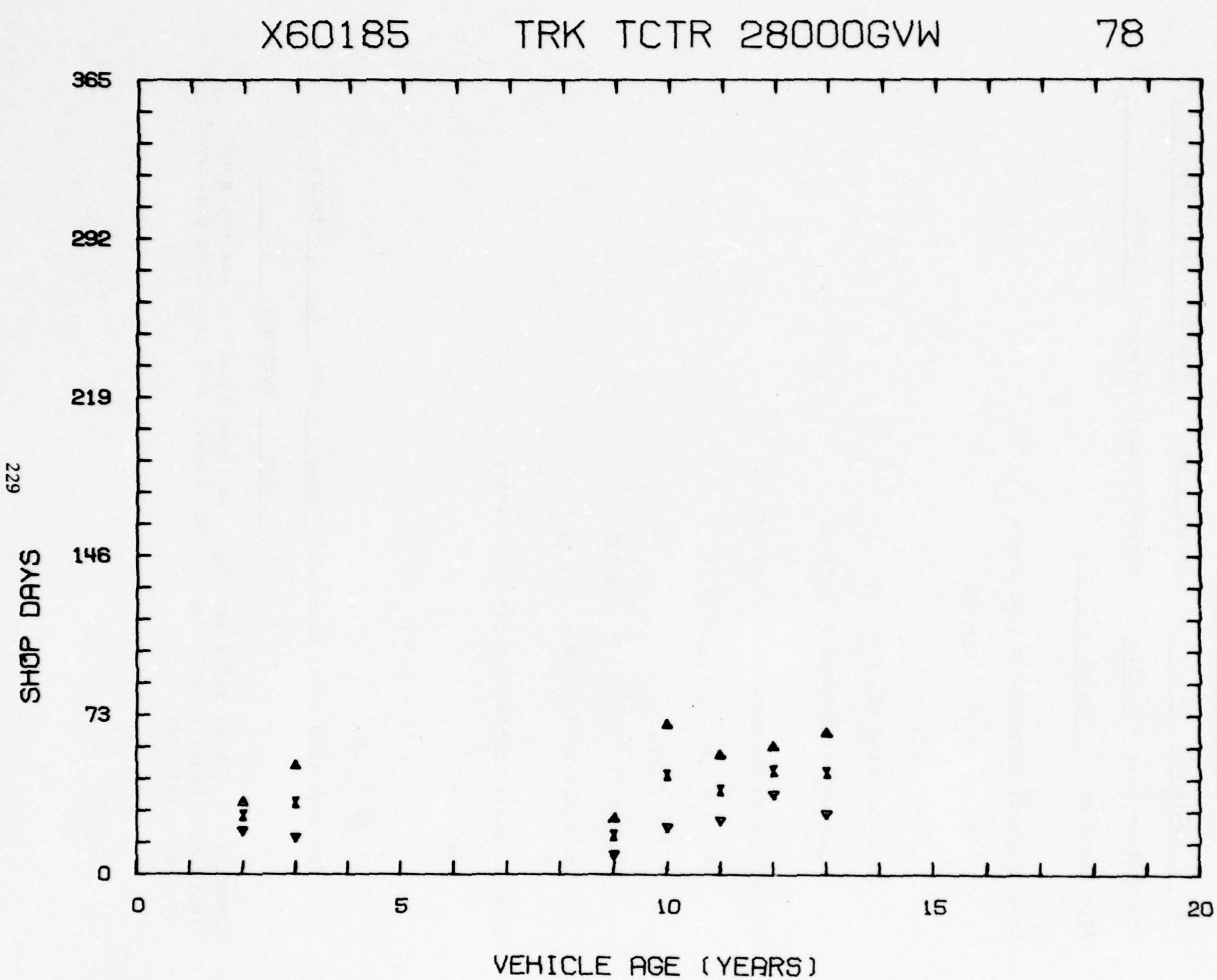

X60185 TRK TCTR 28000GVW 78
ENDING MILEAGE
125000
100000
75000
50000
25000
0
VEHICLE AGE (YEARS)
0
5
10
15
20


X60185 TRK TCTR 28000GVW 78
COST (DOLLARS X 100)
VEHICLE AGE (YEARS)
0
6
12
18
24
30
0
5
10
15
20


X60185 TRK TCTR 28000GVW 78
COST (CENTS)
MILEAGE (MILES X 10,000)
0
6
12
18
24
30
0
5
10
15
20

X60185 TRK TCTR 28000GVW 78




X60185 TRK TCTR 28000GVW 78
SHØP DAYS
365
292
219
146
73
0
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN X60185 NOMENCLATURE Trk Tctr 28000 GVW

Acquisition Cost $18,422 Average Annual Mileage 6600

Fits based on years 1-12

Instantaneous Maintenance Cost Years

$IMC(Y) = 20.76 + 102.40Y$

RSD = 839

Minimum Point ASC Y = 19

Value ASC at Minimum = $1963

Instantaneous Maintenance Cost Miles

$IMC(M) = .008 + 11.56 \cdot 10^{-7}M$

RSD = 814

Minimum Point ASC Y = 178,527

Value ASC at Minimum = 21.4¢

Instantaneous Maintenance Man-hours Years

$IMH(Y) =$

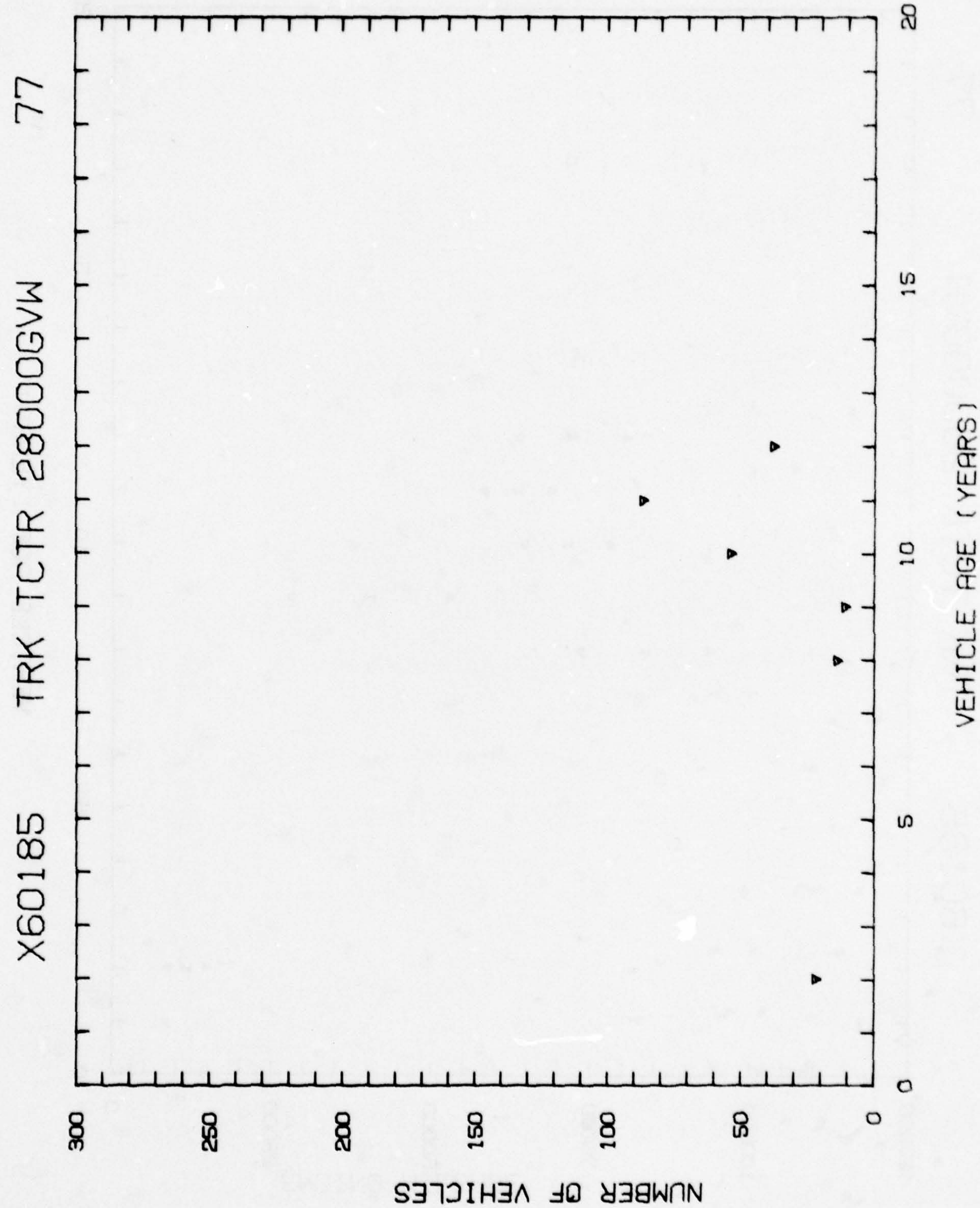
$= 12.54 + 5.77Y$

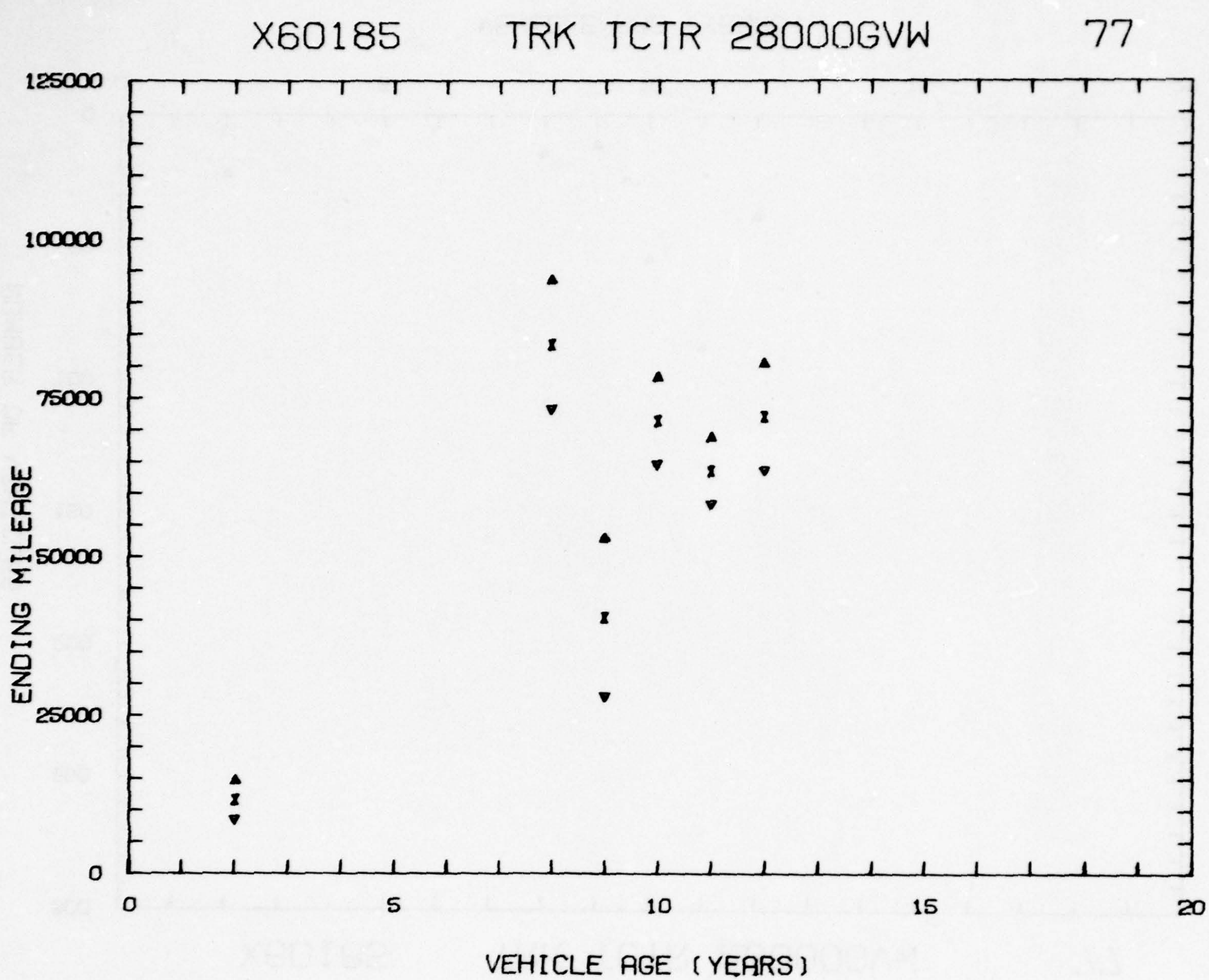
RSD = 41

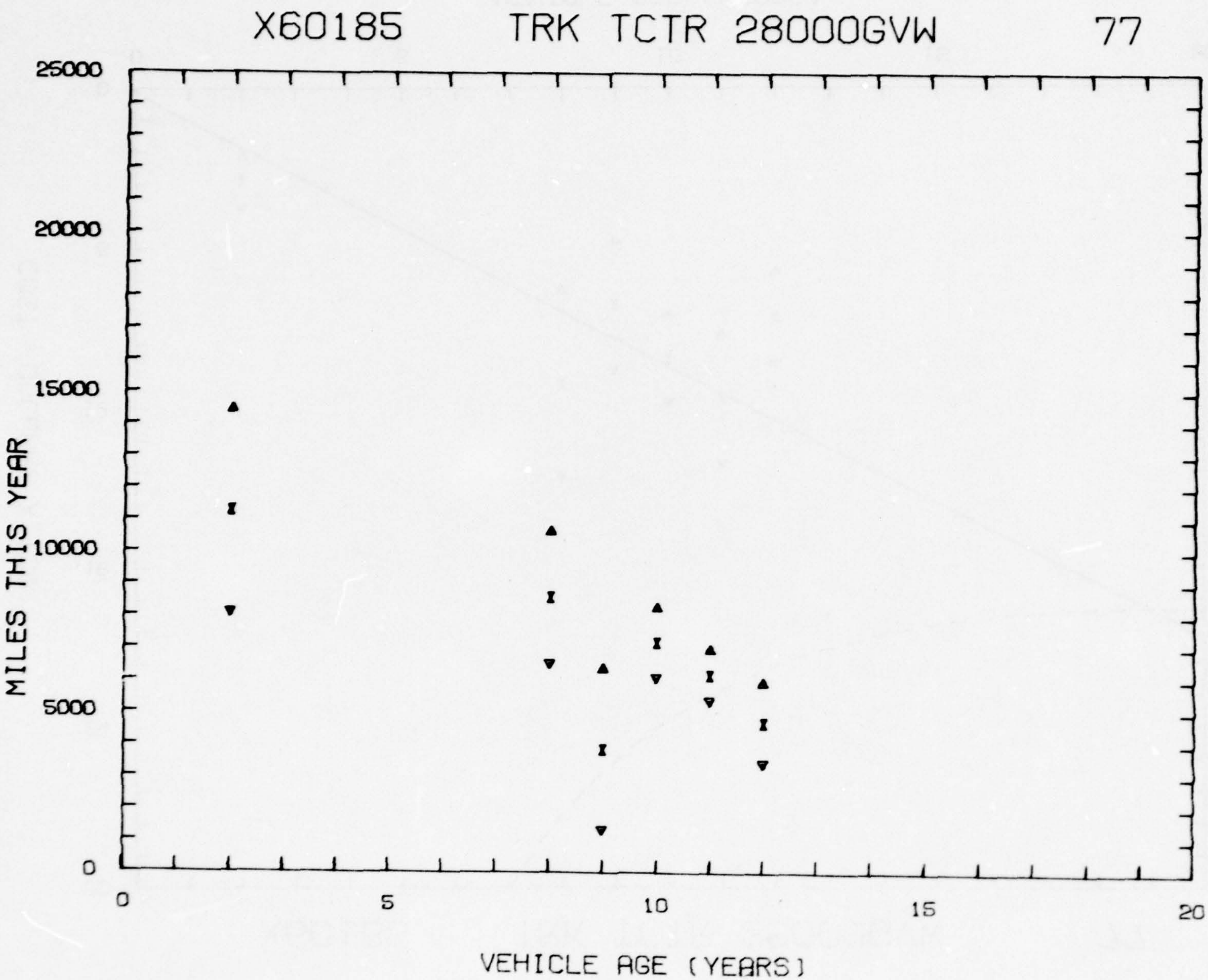
for each 1000 miles more than 6600 add 4.1 hours

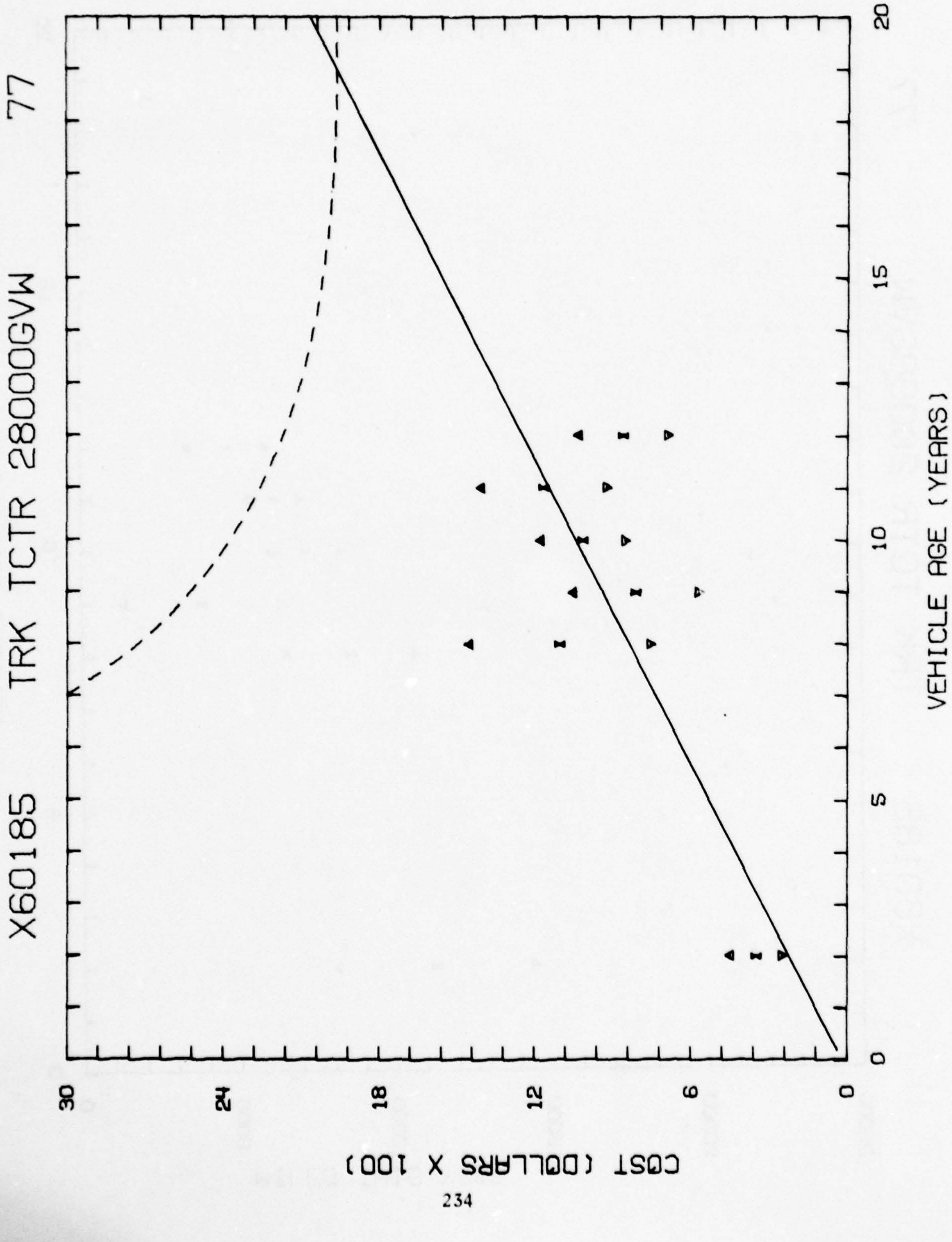
less 6600 subtract 4.1

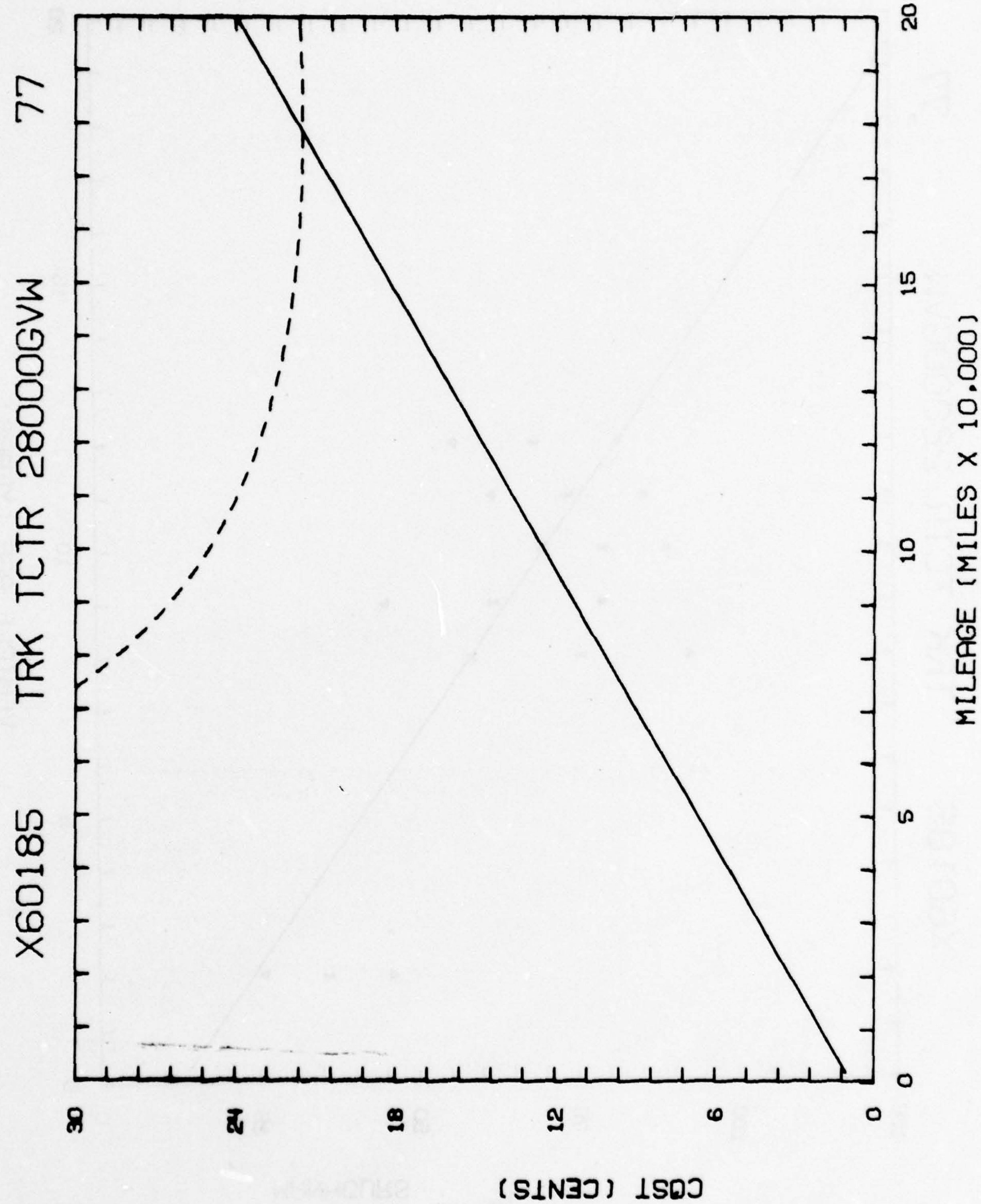
COMMENTS: These RSD's are high, so these equations are not good individual vehicle predictors. Additional work should be performed on these vehicles.

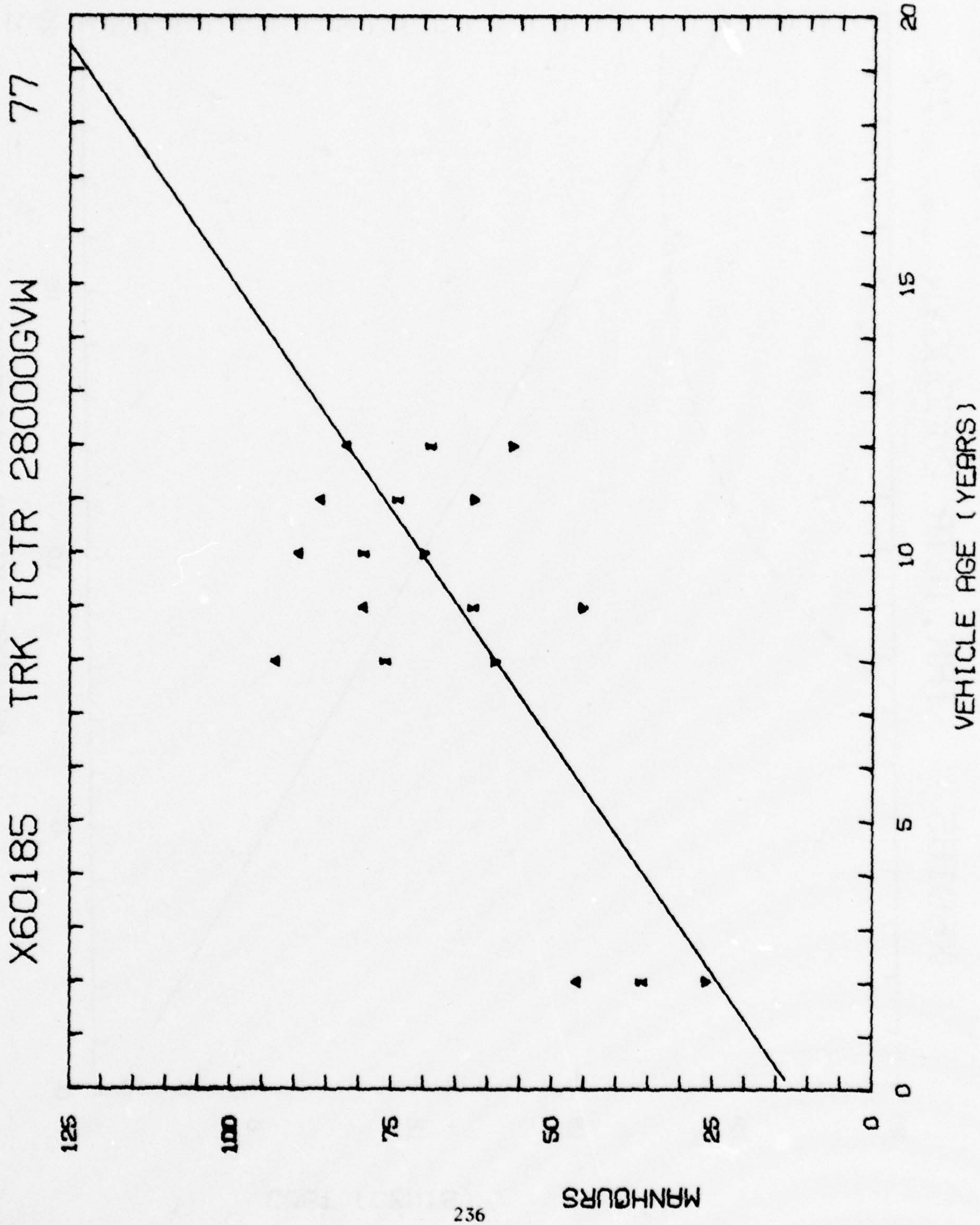

X60185 TRK TCTR 28000GVW 77
NUMBER OF VEHICLES
VEHICLE AGE (YEARS)
0
50
100
150
200
250
300
0
5
10
15
20

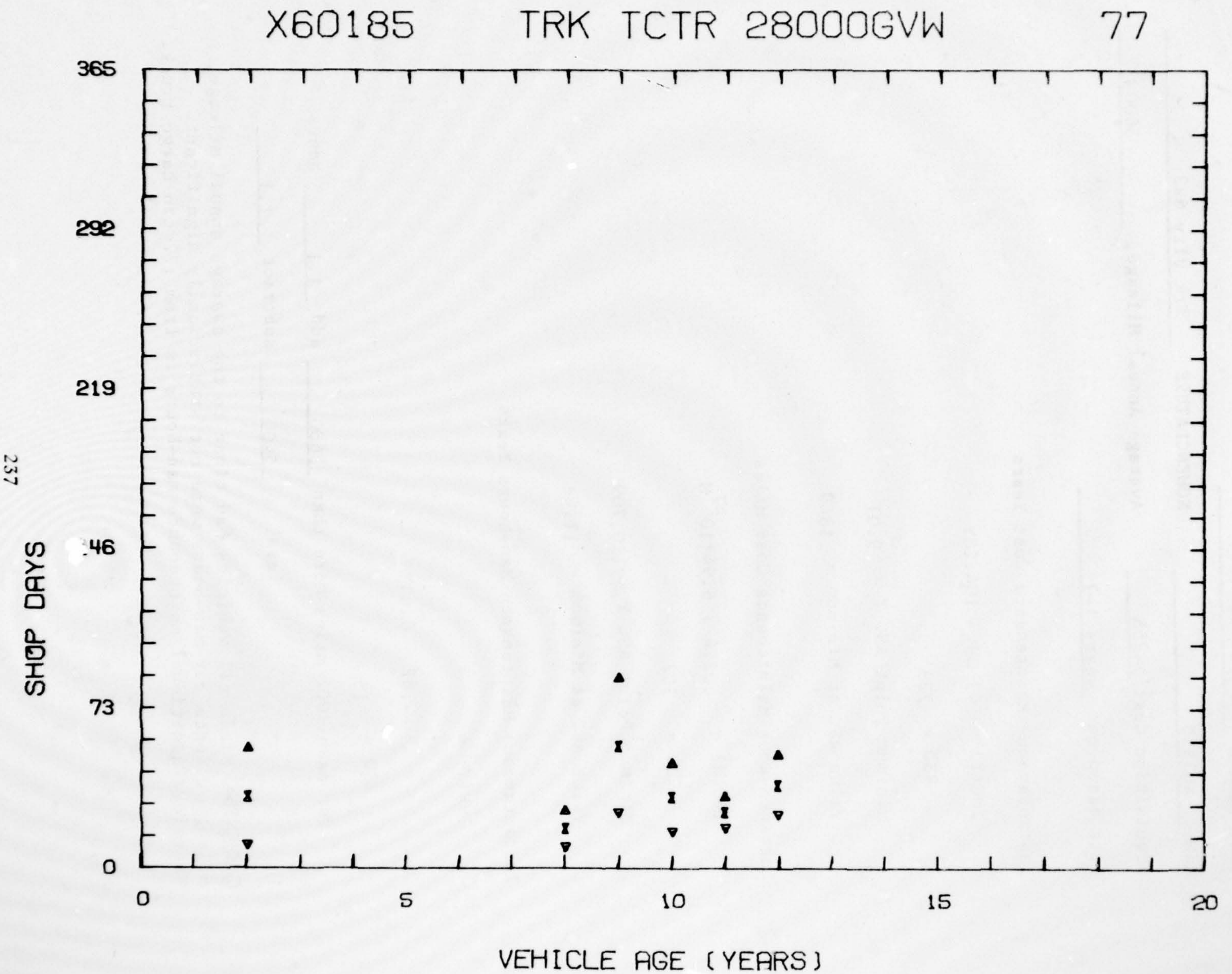

X60185 TRK TCTR 28000GVW 77
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)


X60185 TRK TCTR 28000GVW 77
MILES THIS YEAR
VEHICLE AGE (YEARS)
25000
20000
15000
10000
5000
0
0
5
10
15
20


X60185 TRK TCTR 28000GVW 77
COST (DOLLARS X 100)
0
6
12
18
24
30
VEHICLE AGE (YEARS)
0
5
10
15
20


X60185 TRK TCTR 28000GVW 77
COST (CENTS)
0
6
12
18
24
30
MILEAGE (MILES X 10.000)
0
5
10
15
20


X60185 TRK TCTR 28000GVW 77
MANHOURS
0
25
50
75
100
125
0
5
10
15
20
VEHICLE AGE (YEARS)


X60185 TRK TCTR 28000GVW 77
365
292
219
146
73
0
SHOP DAYS
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 78

LIN X61518 NOMENCLATURE Trk Ulty 4x2

Acquisition Cost $4253 Average Annual Mileage 5600

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 93.09 + 104.28Y$

RSD = 228

Minimum Point ASC Y = 9.01

Value ASC at Minimum = $849

Instantaneous Maintenance Cost Miles

$IMC(M) = .0374 + 6.94 \cdot 10^{-7} M$

RSD = 302

Minimum Point ASC Y = 110,709

Value ASC at Minimum = 11.4¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

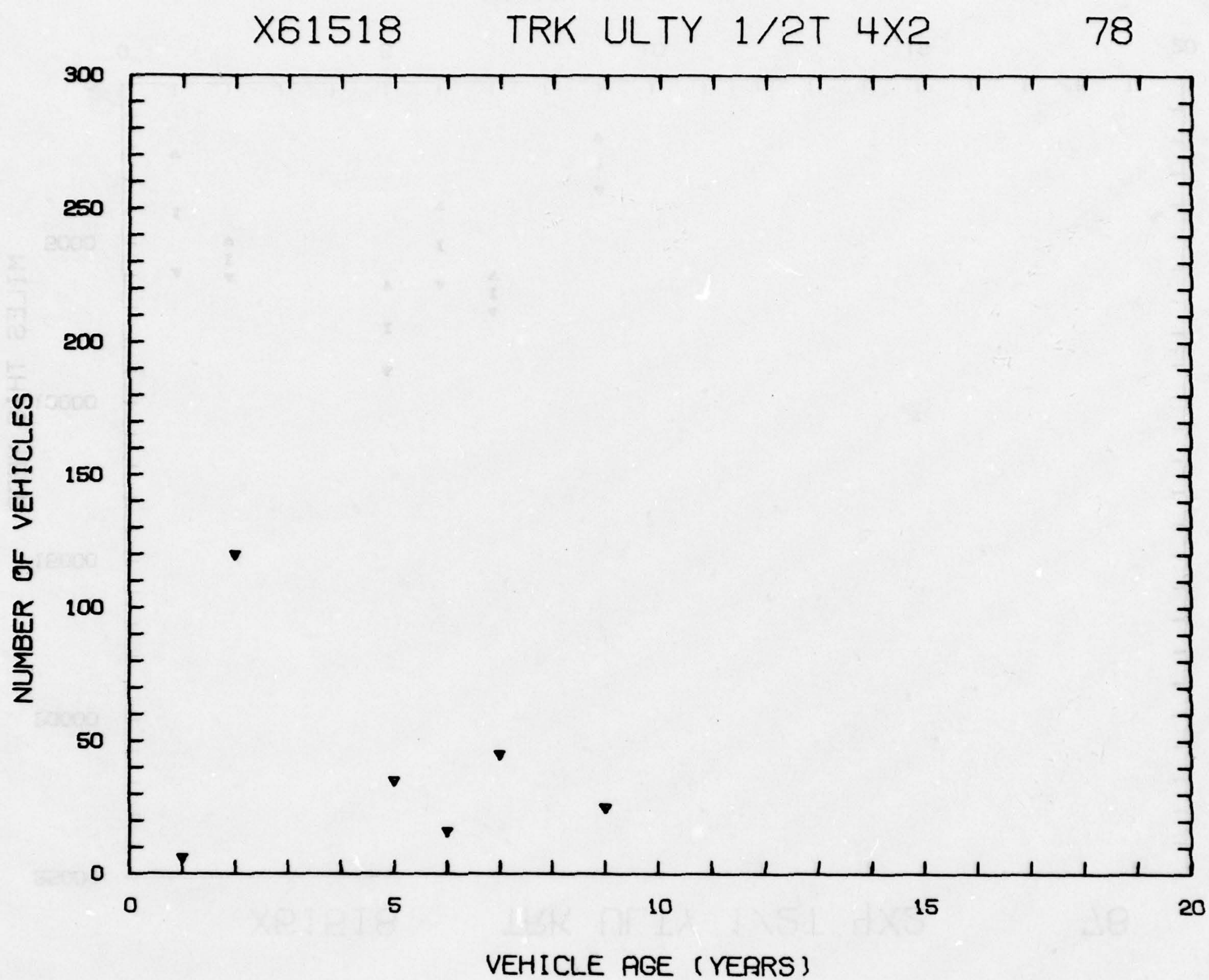
$= -.82 + 6.43Y$

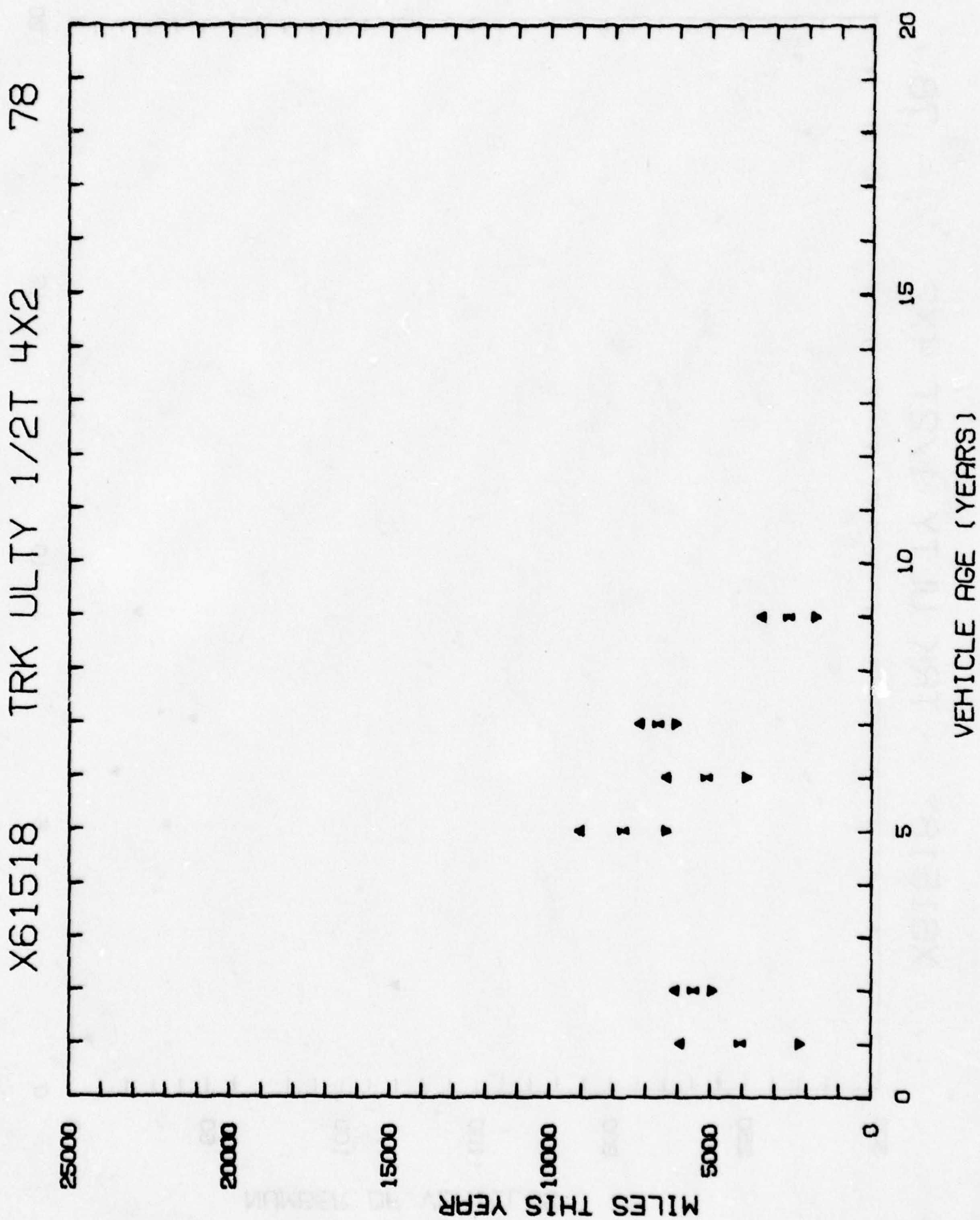
RSD = 15

for each 1000 miles more than 5600 add 1.1 hours

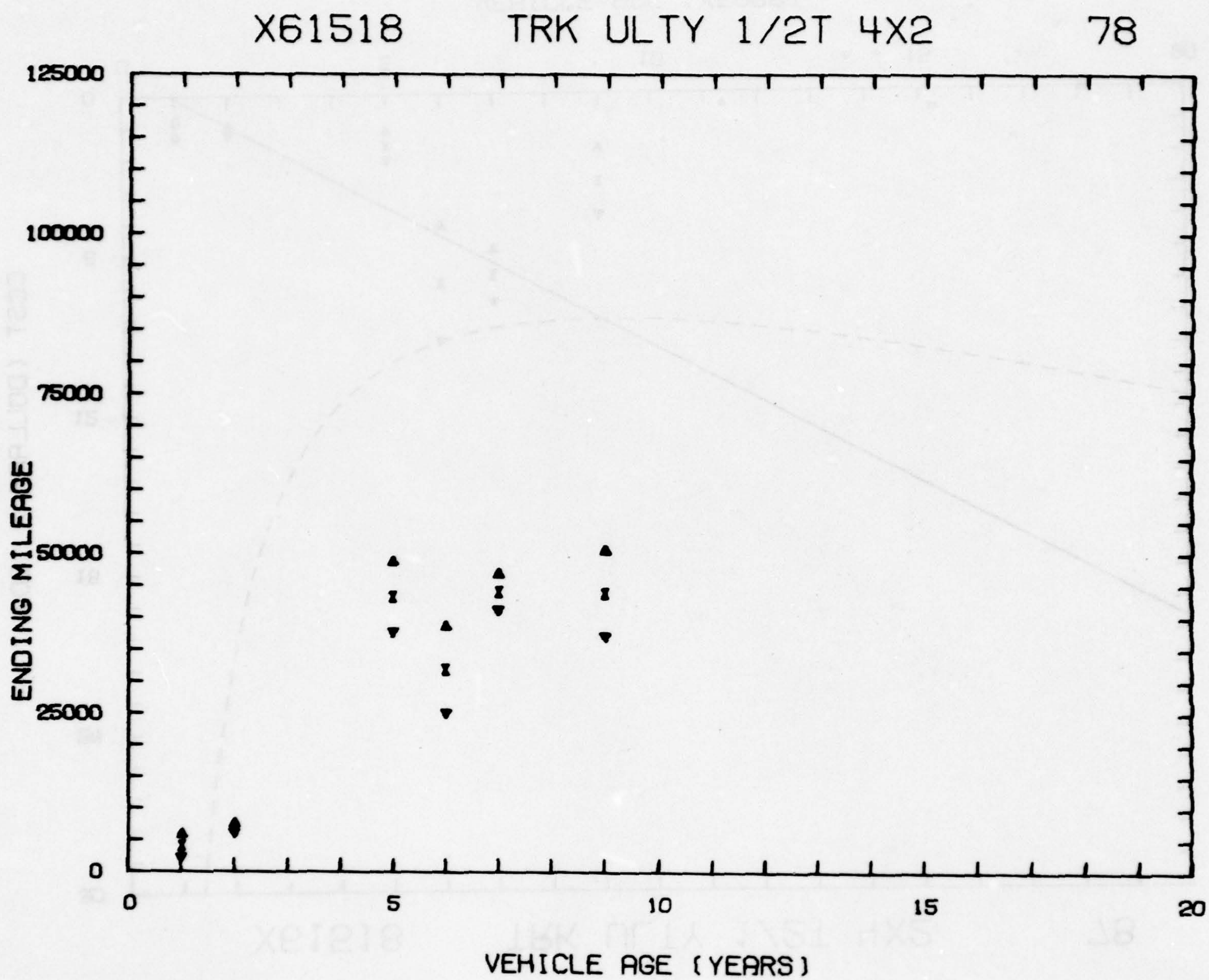
less 5600 subtract 1.1

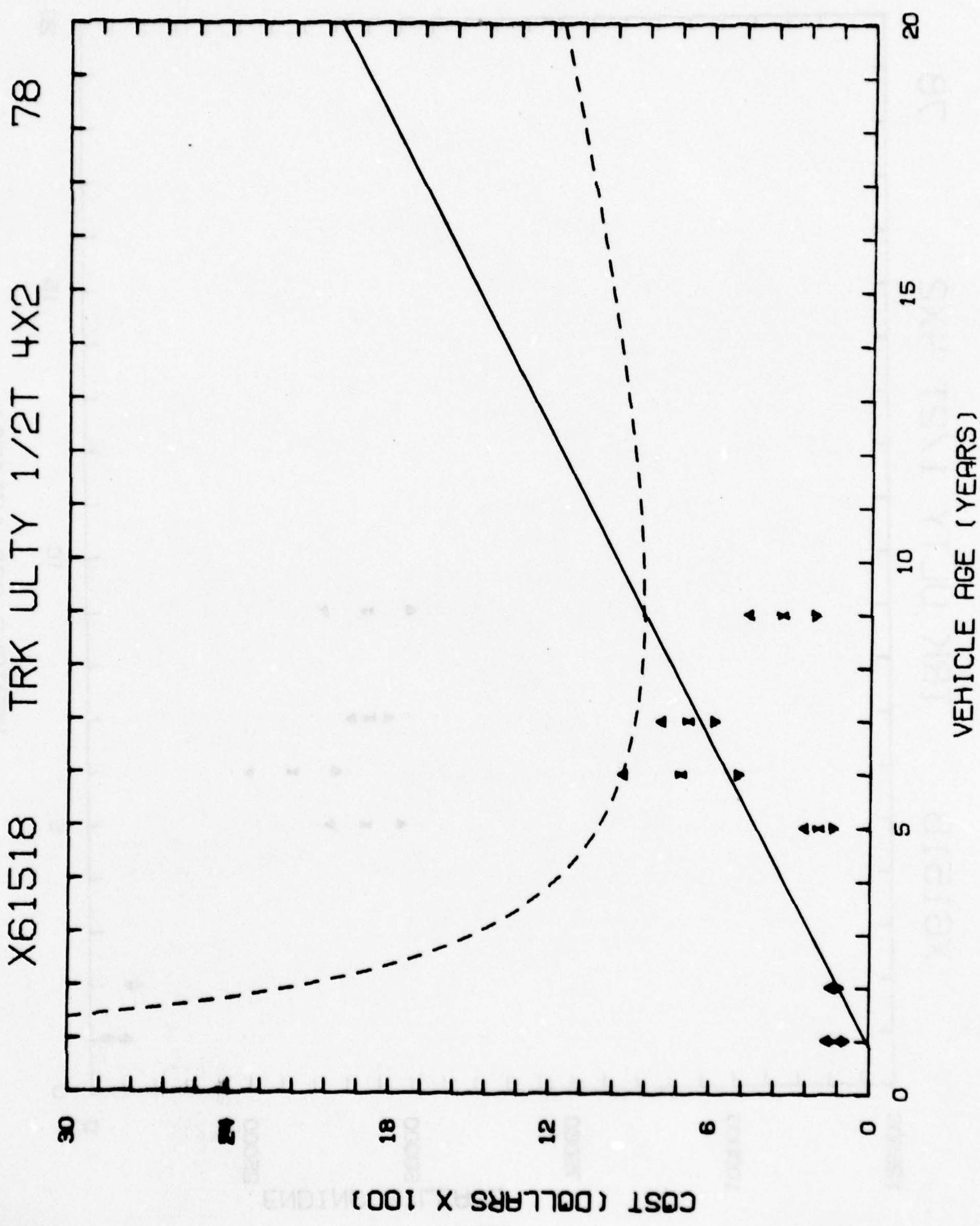
COMMENTS: Since all vehicles had close to the average annual mileage, mileage effects for man-hours were not statistically significant. Therefore additional maintenance man-hours is from 1/2 ton cargo truck.

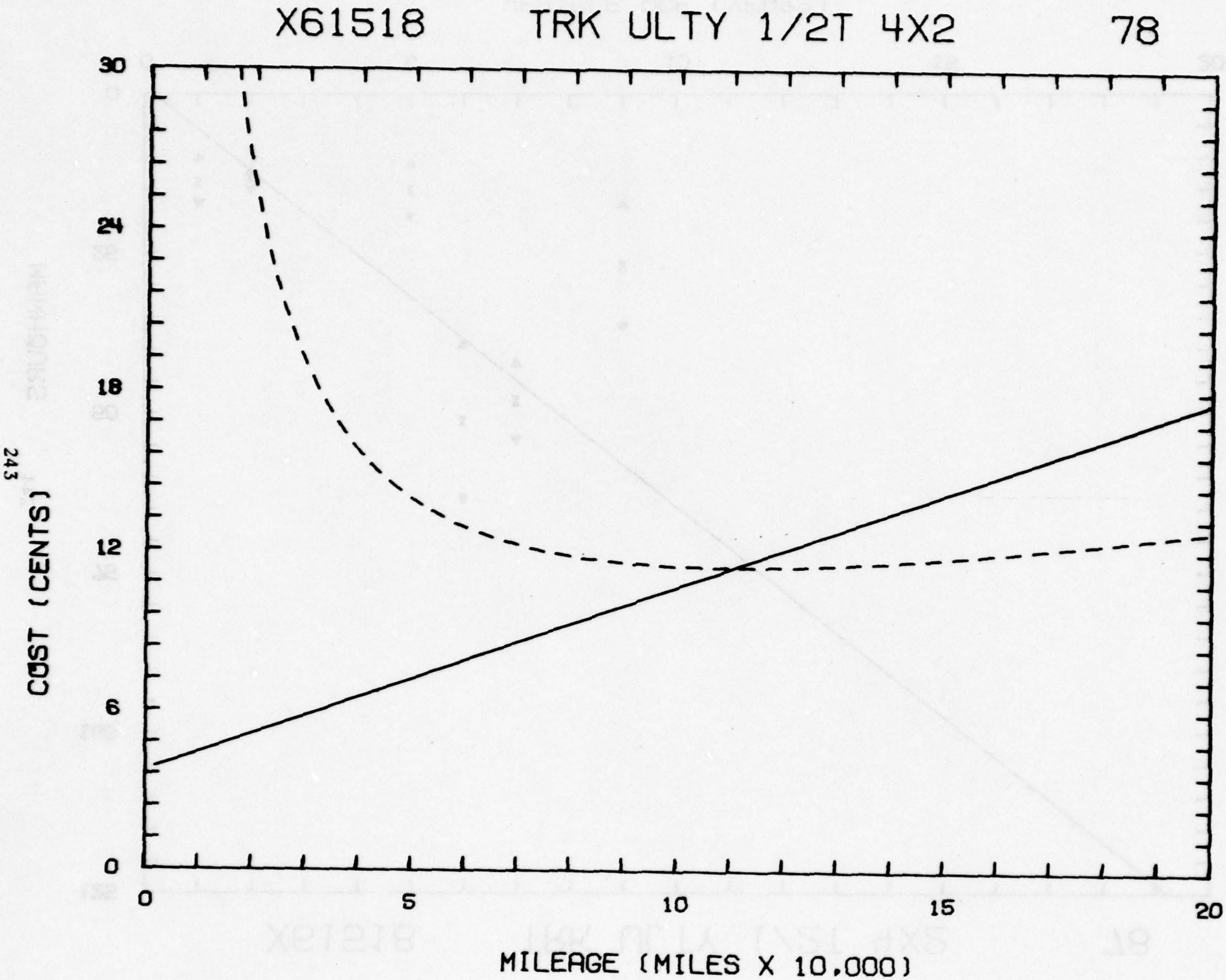

X61518 TRK ULTY 1/2T 4X2 78
NUMBER OF VEHICLES
300
250
200
150
100
50
0
0
5
10
15
20
VEHICLE AGE (YEARS)

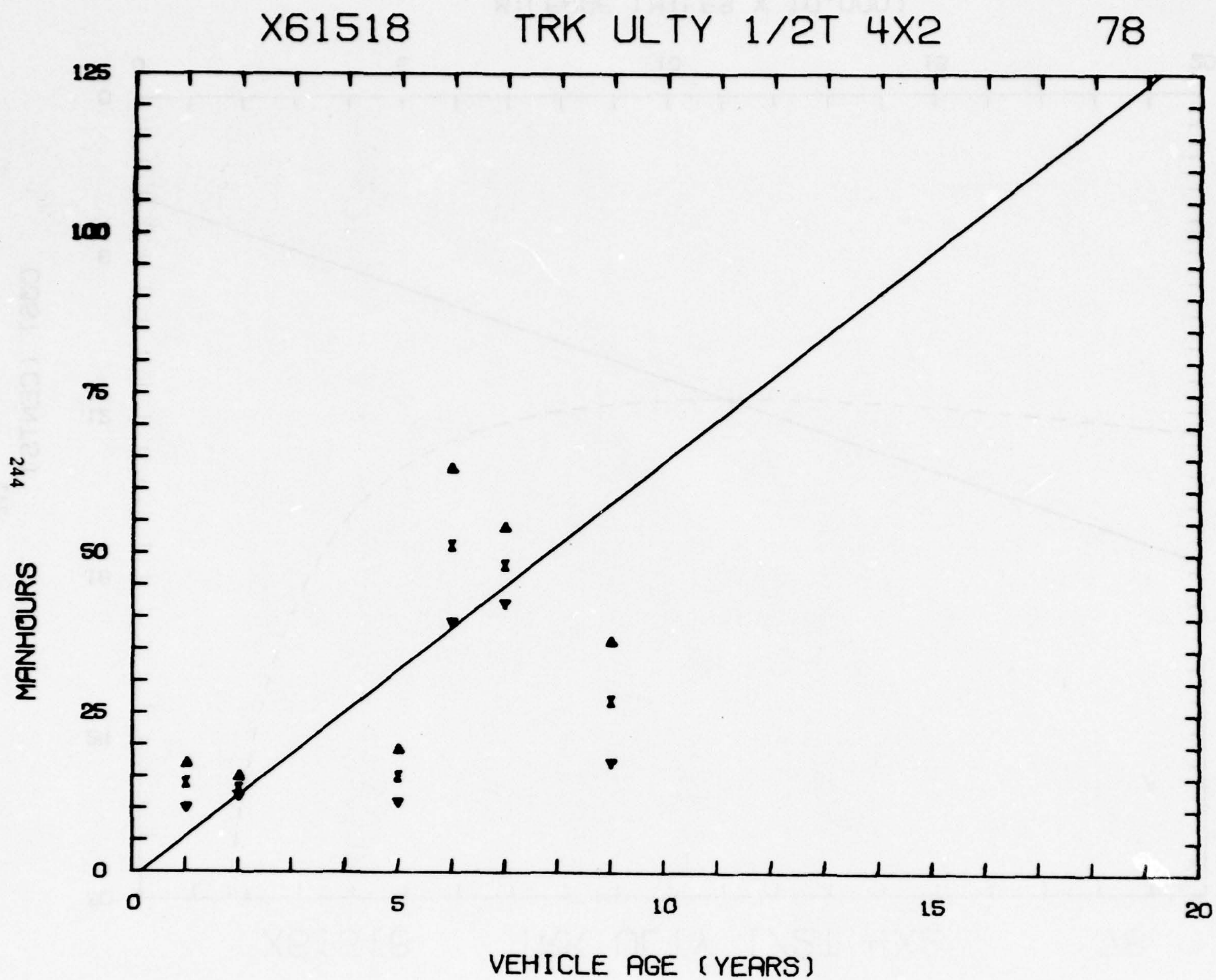


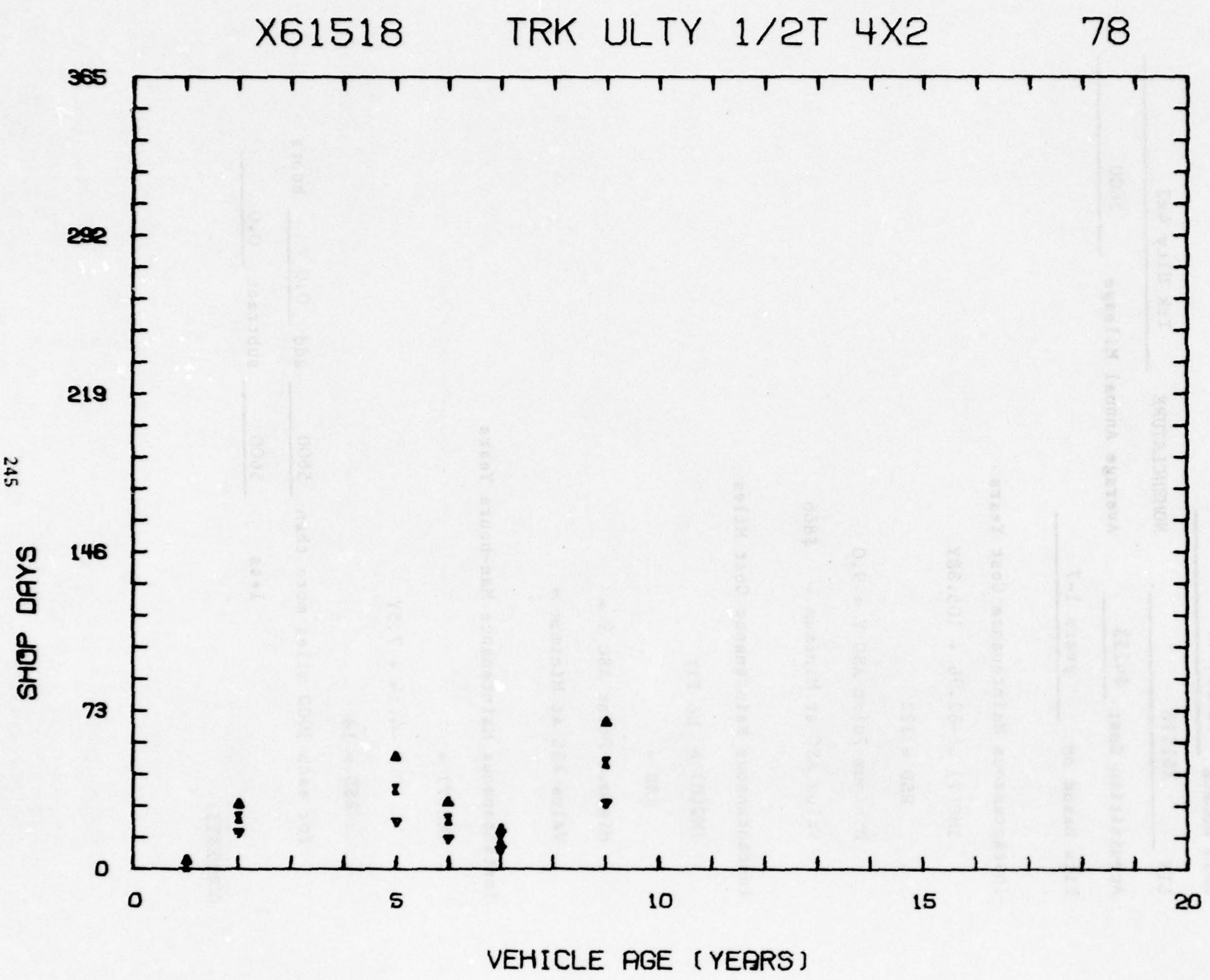
X61518 TRK ULTY 1/2T 4X2 78
MILES THIS YEAR
VEHICLE AGE (YEARS)
0
5000
10000
15000
20000
25000
0
5
10
15
20


X61518
TRK ULTY 1/2T 4X2
78
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)


X61518 TRK ULTY 1/2T 4X2 78
COST (DOLLARS X 100)
VEHICLE AGE (YEARS)
0
5
10
15
20
0
6
12
18
30


X61518
TRK ULTY 1/2T 4X2
78
30
24
18
12
6
0
COST (CENTS)
0
5
10
15
20
MILEAGE (MILES X 10,000)


X61518 TRK ULTY 1/2T 4X2 78
125
100
75
50
25
0
MANHOURS
0
5
10
15
20
VEHICLE AGE (YEARS)


X61518 TRK ULTY 1/2T 4X2 78
SHOP DAYS
365
292
219
146
73
0
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN X61518 NOMENCLATURE Trk Ulty 4x2

Acquisition Cost $4253 Average Annual Mileage 5600

Fits based on years 1-7

Instantaneous Maintenance Cost Years

IMC(Y) = -82.96 + 105.88Y

RSD = 322

Minimum Point ASC Y = 9.0

Value ASC at Minimum = $866

Instantaneous Maintenance Cost Miles

IMC(M) = No Fit

RSD =

Minimum Point ASC Y =

Value ASC at Minimum =

Instantaneous Maintenance Man-hours Years

IMH(Y) =

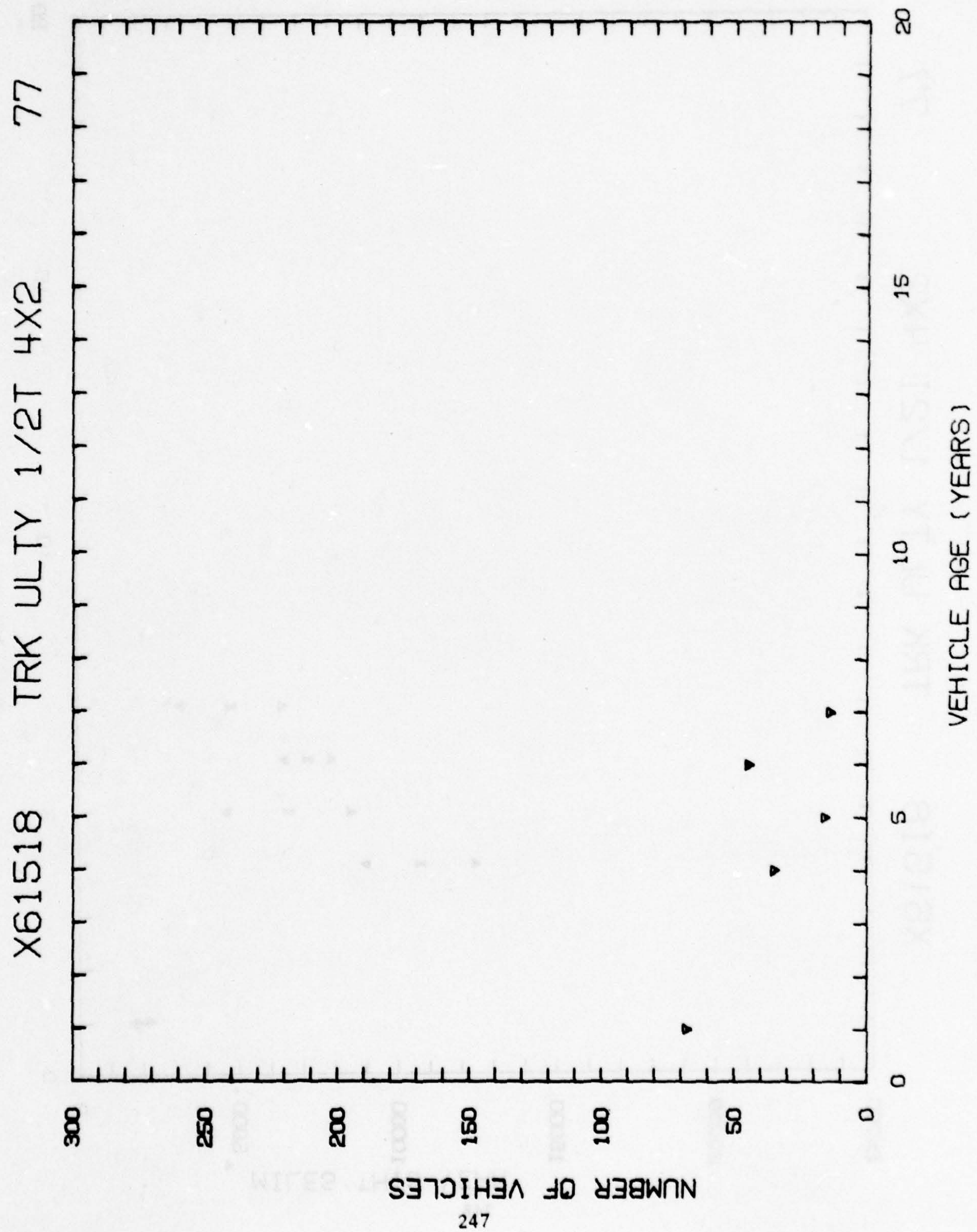
= -4.34 + 7.5Y

RSD = 18

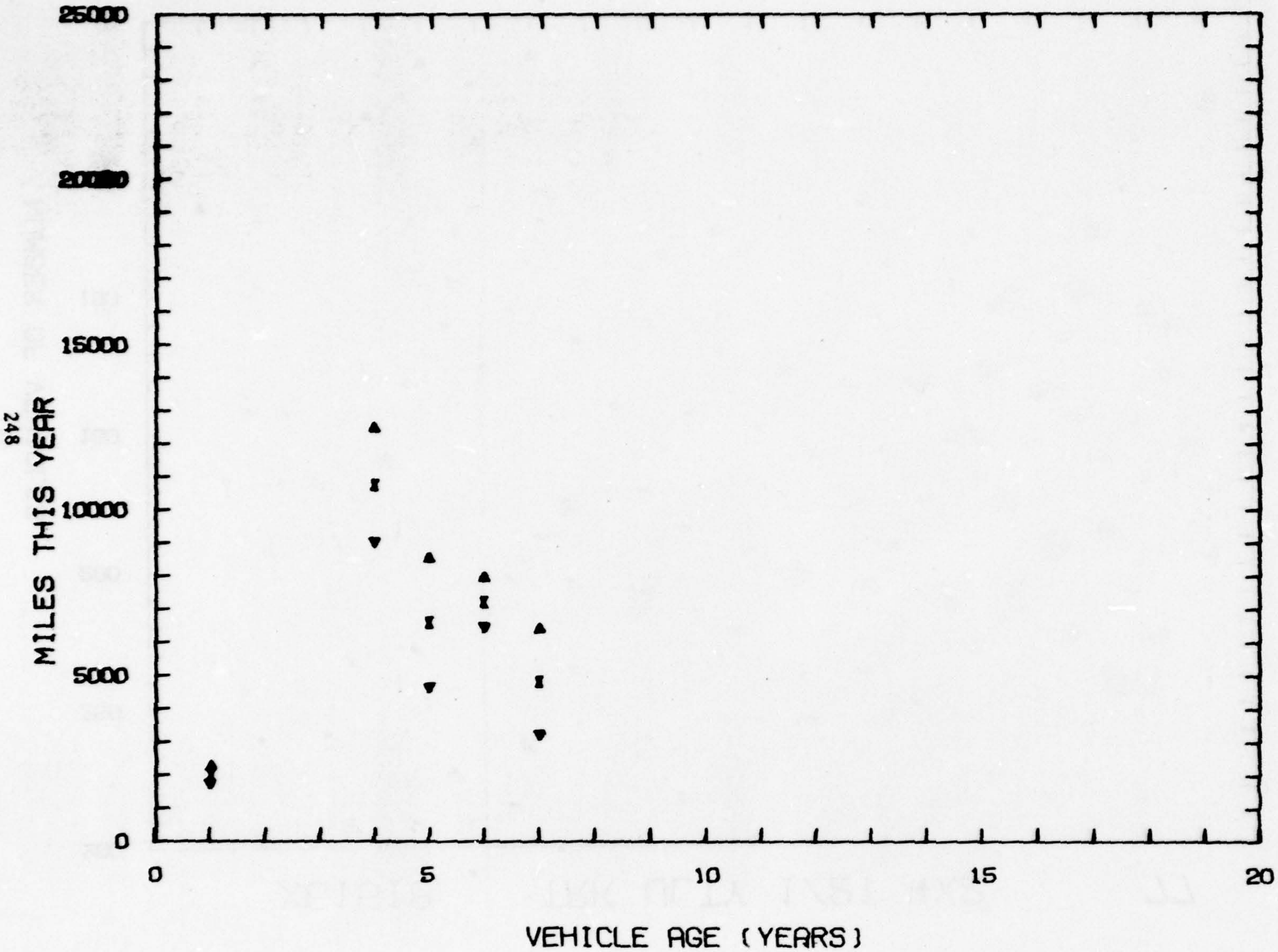
for each 1000 miles more than 5600 add 0.0 hours

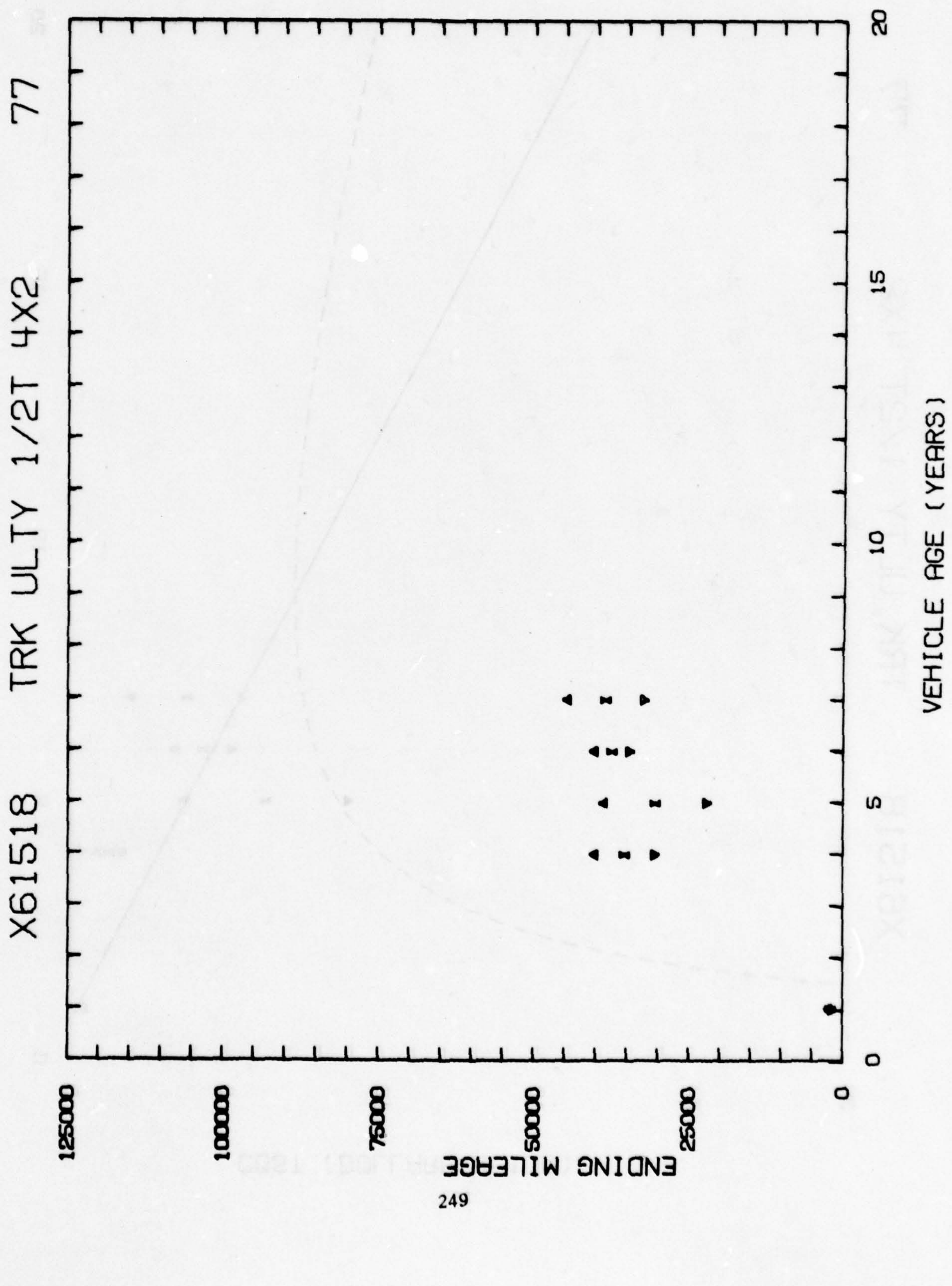
less 5600 subtract 0.0

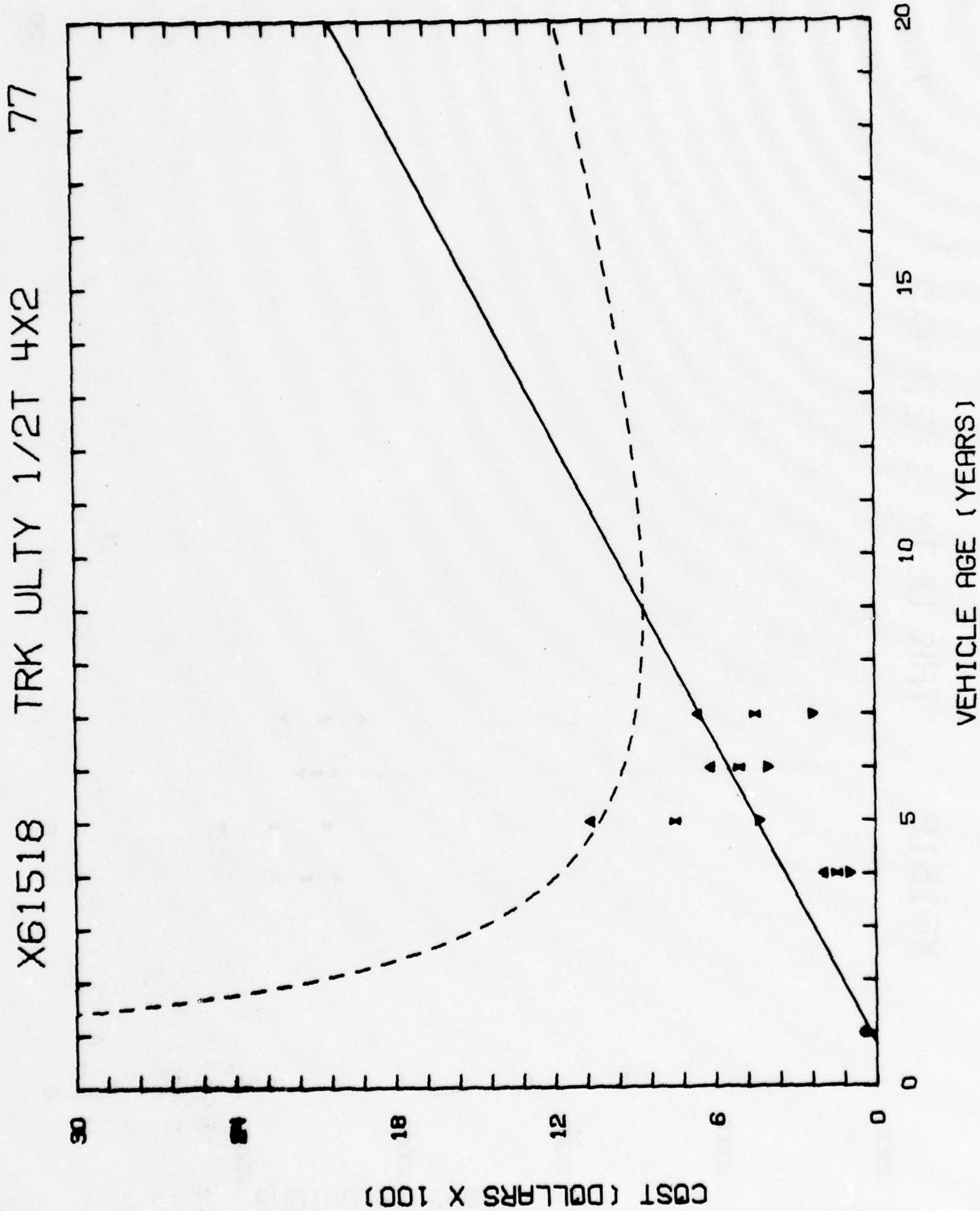
COMMENTS:


X61518 TRK ULTY 1/2T 4X2 77
NUMBER OF VEHICLES
0
50
100
150
200
250
300
VEHICLE AGE (YEARS)
0
5
10
15
20

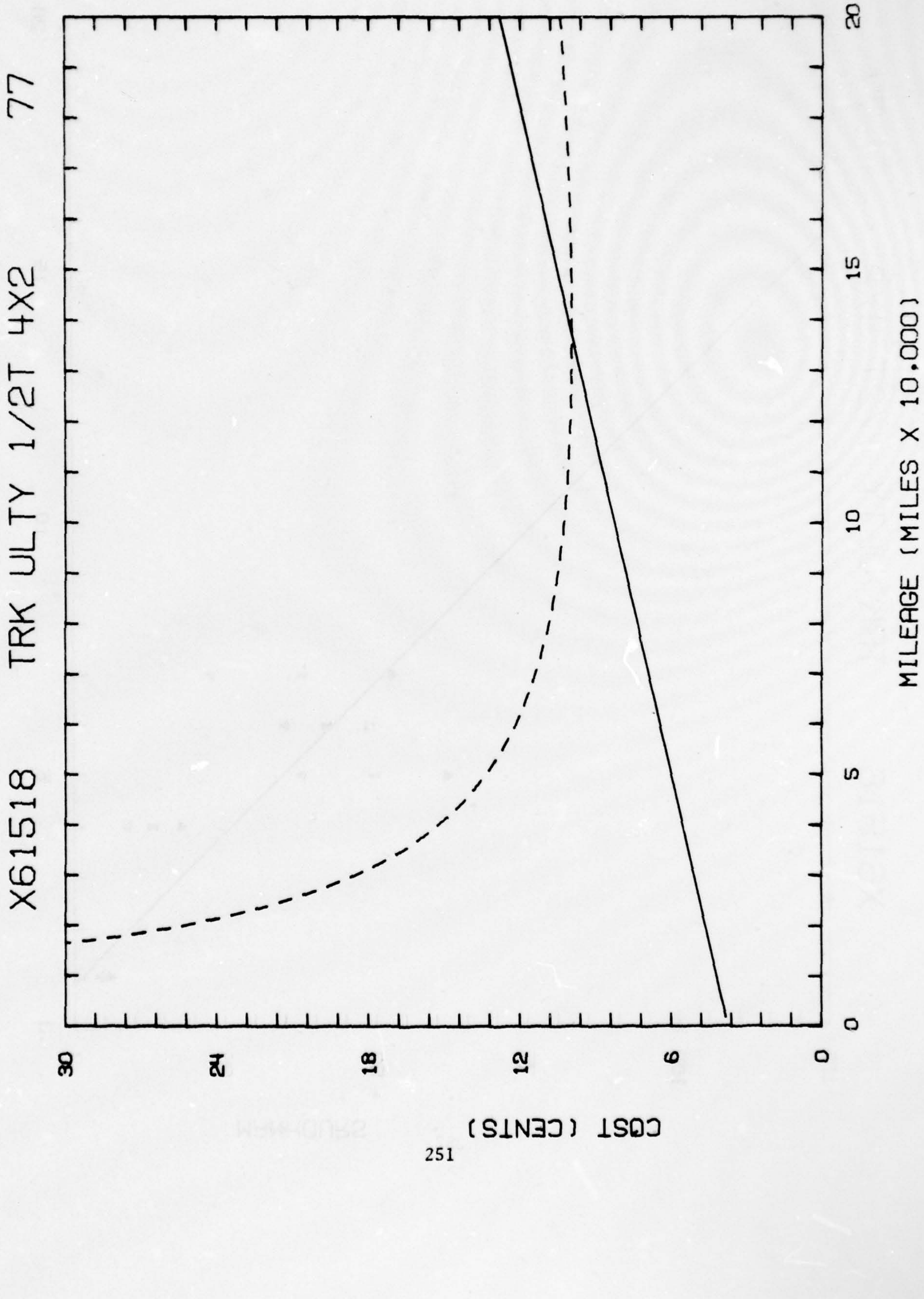
X61518 TRK ULTY 1/2T 4X2 77

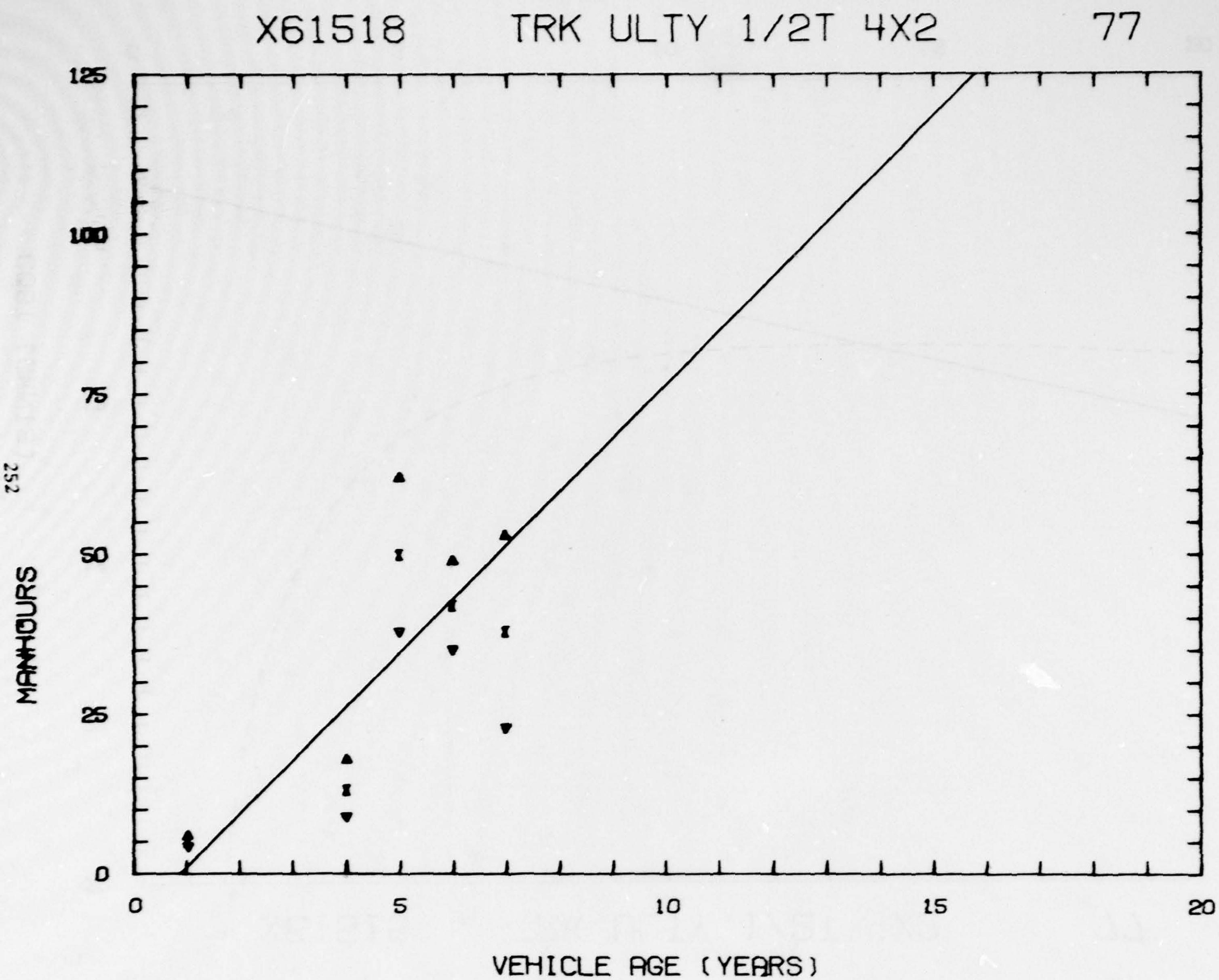


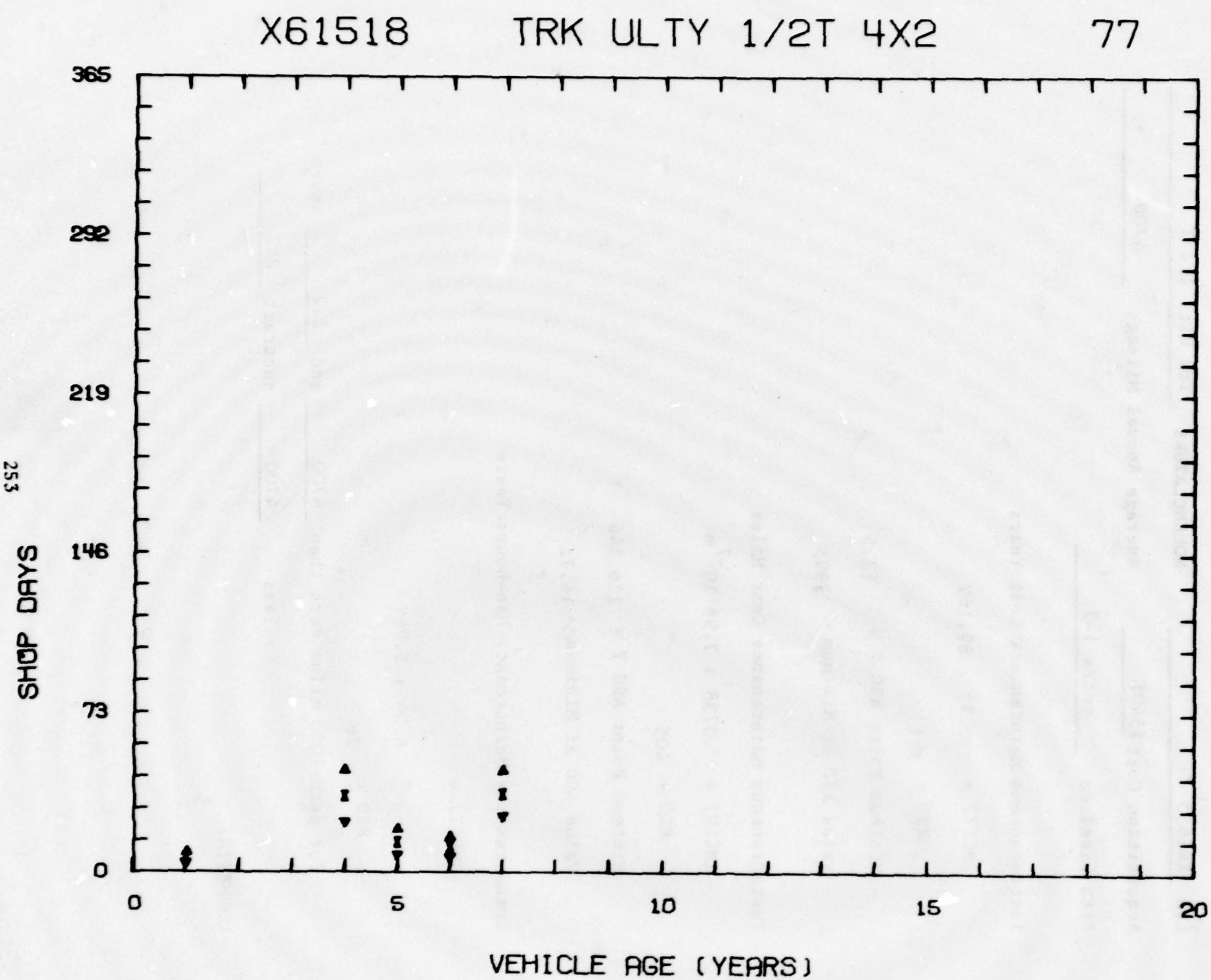

X61518 TRK ULTY 1/2T 4X2 77
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)



X61518
TRK ULTY 1/2T 4X2
77
VEHICLE AGE (YEARS)
COST (DOLLARS X 100)
0
5
10
15
20
0
6
12
18
30


X61518 TRK ULTY 1/2T 4X2 77
COST (CENTS)
0
6
12
18
24
30
MILEAGE (MILES X 10,000)
0
5
10
15
20


X61518 TRK ULTY 1/2T 4X2 77
MANHOURS
125
100
75
50
25
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X61518 TRK ULTY 1/2T 4X2 77
SHOP DAYS
365
292
219
146
73
0
VEHICLE AGE (YEARS)
0
5
10
15
20

DATA SOURCE TRADOC 78

LIN X61655 **NOMENCLATURE** Trk Ulty 1/2 T

Acquisition Cost $5401 **Average Annual Mileage** 4700

Fits based on years 1-7

Instantaneous Maintenance Cost Years

$IMC(Y) = 130.73 + 69.16Y$

RSD = 383

Minimum Point ASC Y = 12.5

Value ASC at Minimum = $995

Instantaneous Maintenance Cost Miles

$IMC(M) = .0738 + 7.98 \cdot 10^{-7} m$

RSD = 405

Minimum Point ASC Y = 116,346

Value ASC at Minimum = 16.7¢

Instantaneous Maintenance Man-hours Years

IMH(Y) =

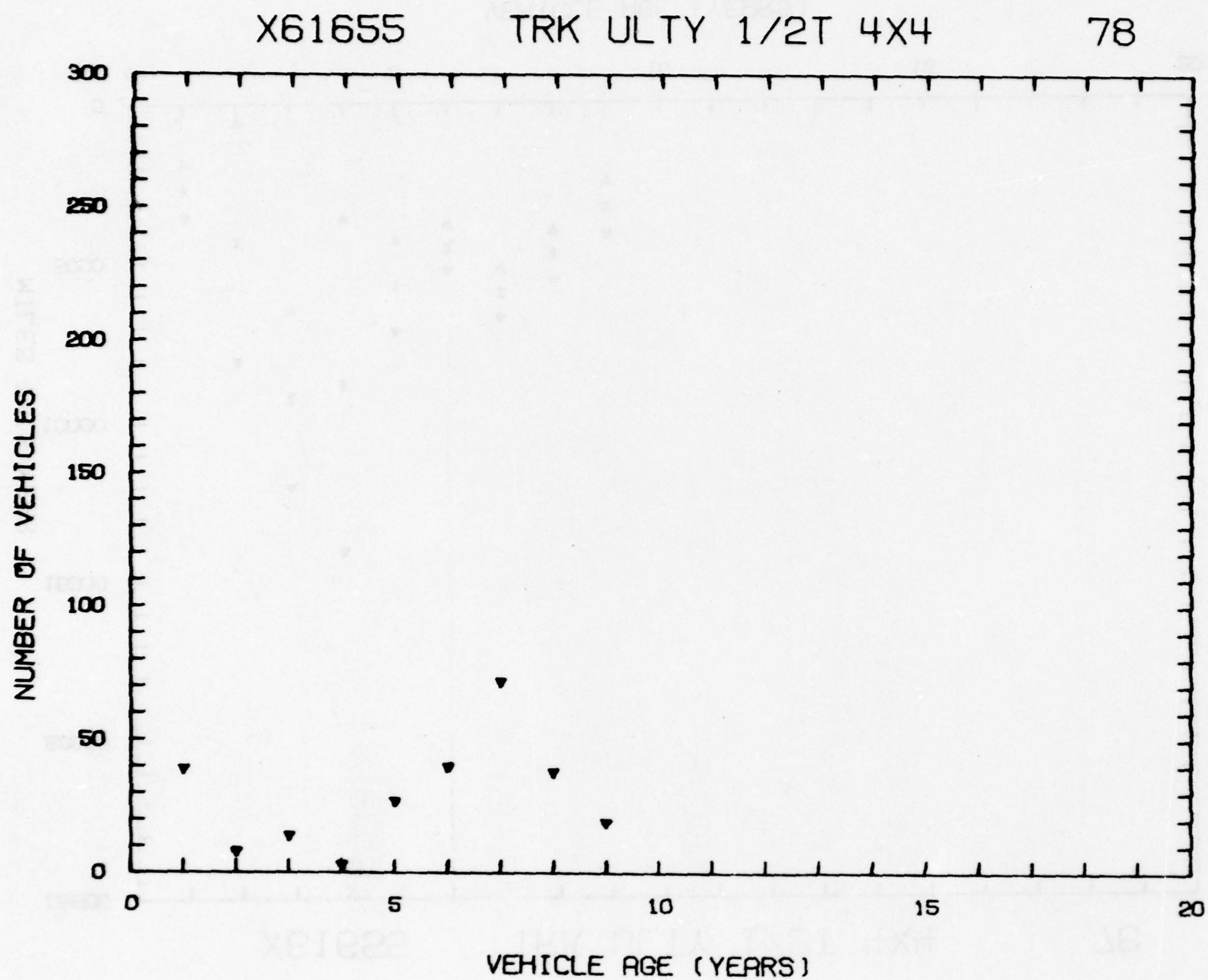
$= 8.04 + 5.96Y$

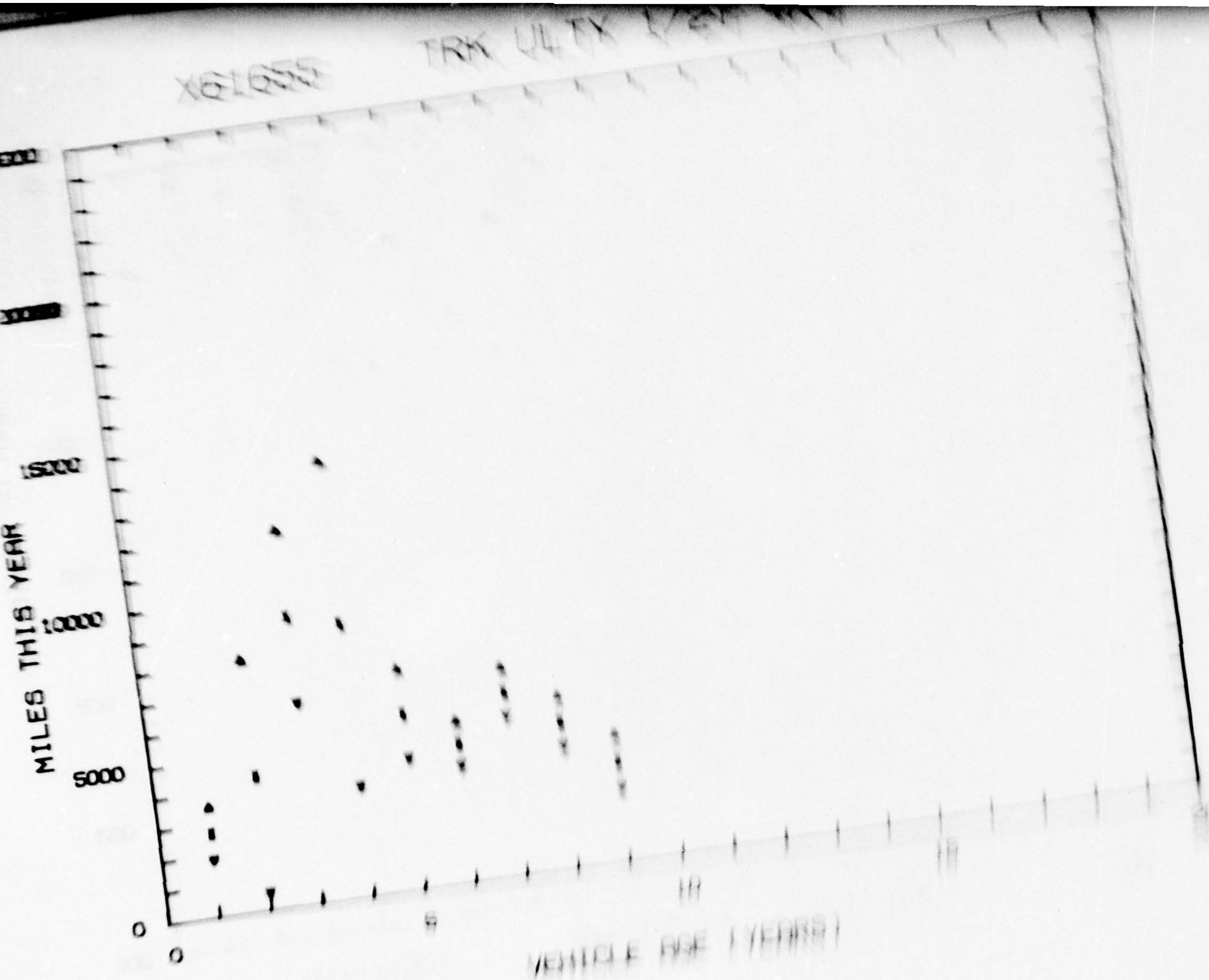
RSD = 26

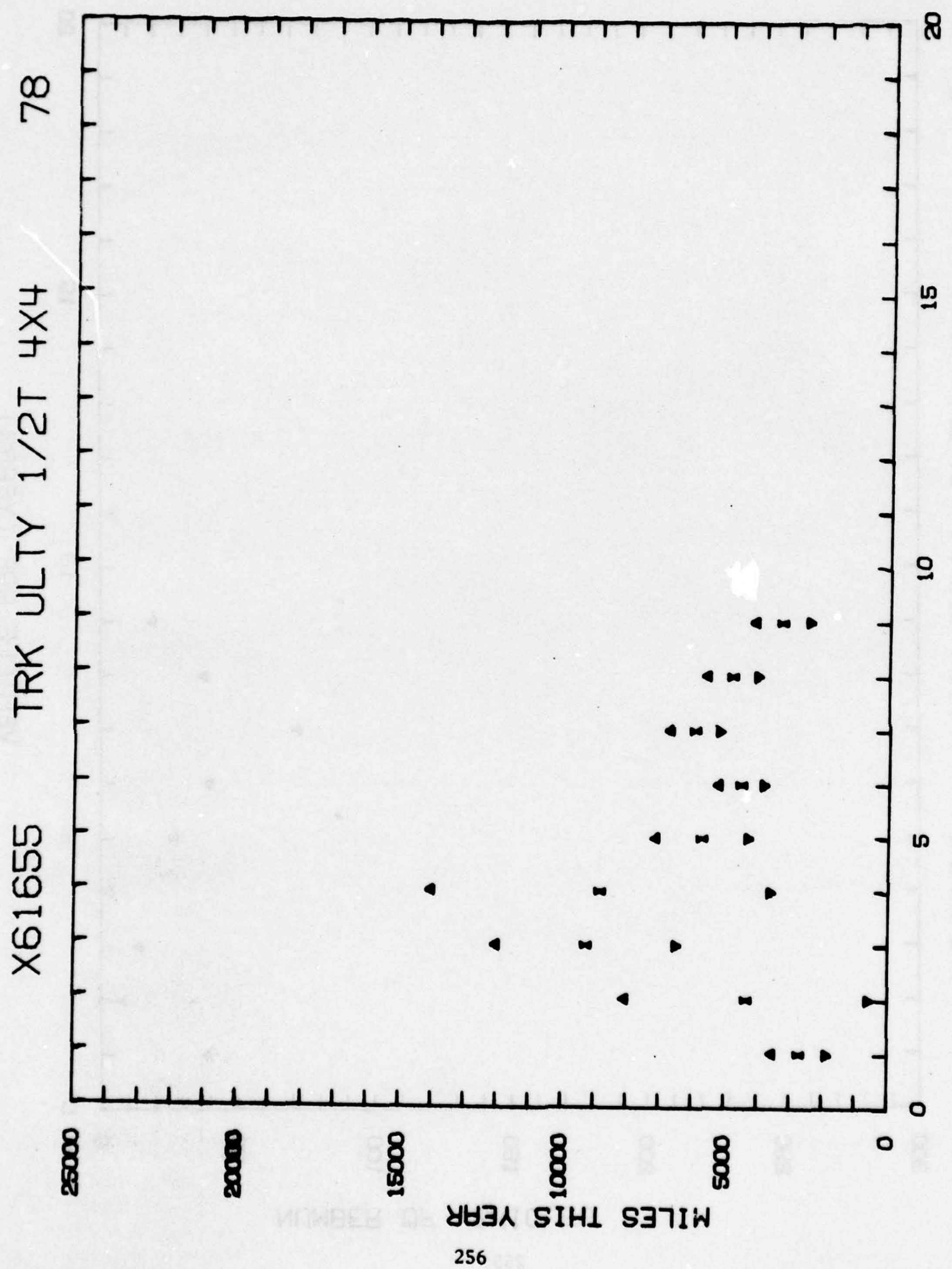
for each 1000 miles more than 4700 add 2.2 hours

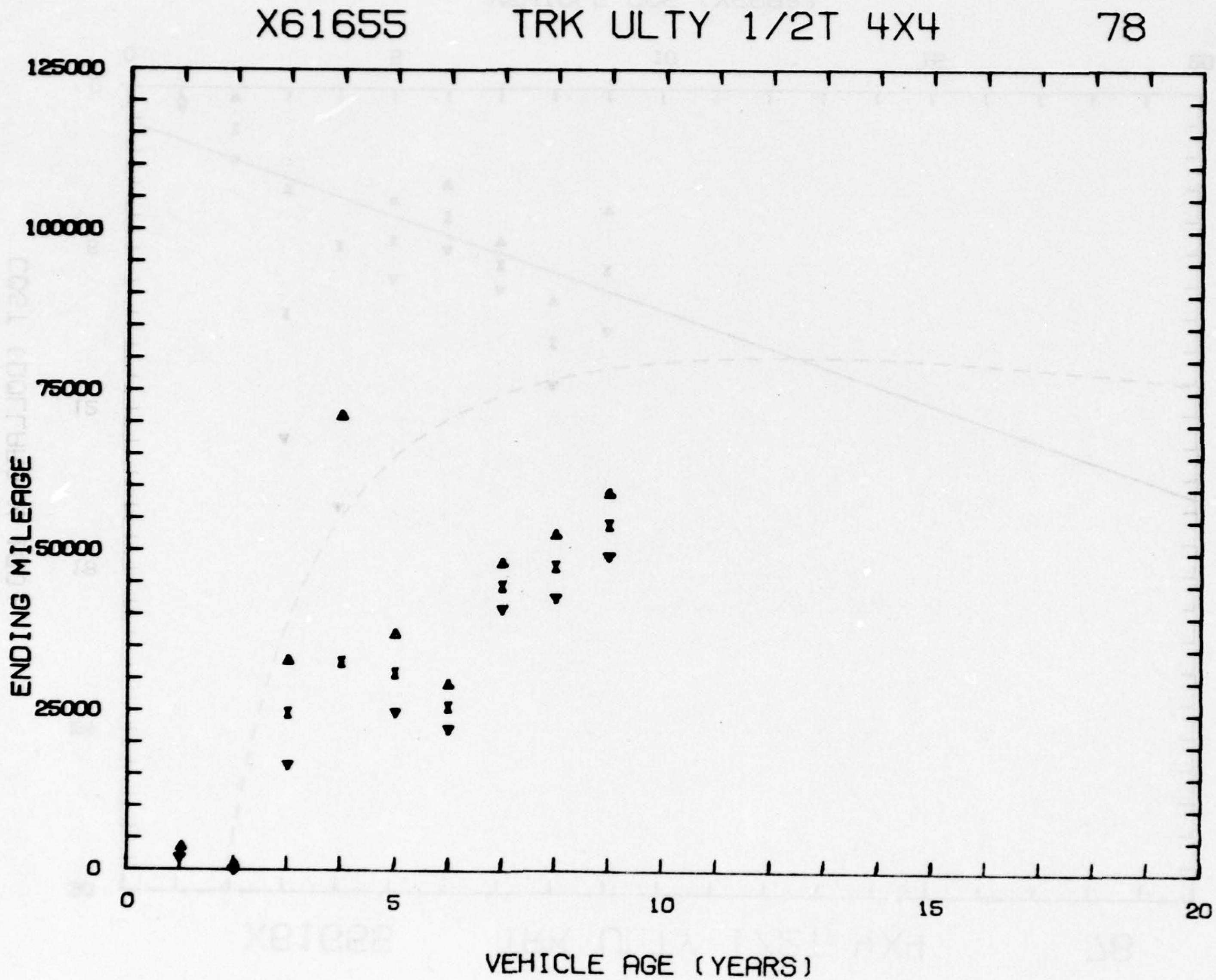
less 4700 subtract 2.2

COMMENTS:

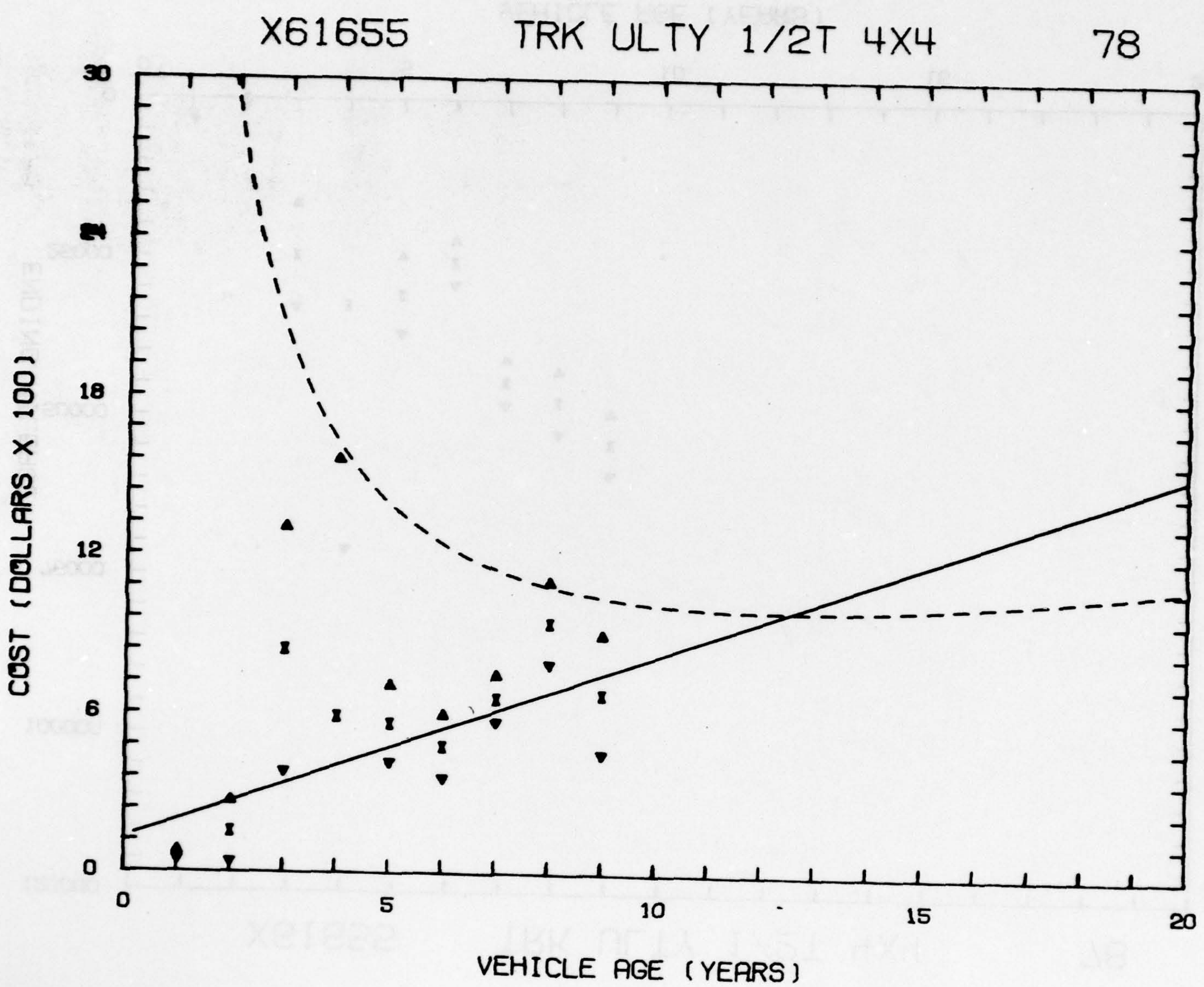

X61655 TRK ULTY 1/2T 4X4 78
NUMBER OF VEHICLES
300
250
200
150
100
50
0
0
5
10
15
20
VEHICLE AGE (YEARS)


X61655 TRK ULTX
MILES THIS YEAR
25000
20000
15000
10000
5000
0
0
5
10
15
20
VEHICLE AGE (YEARS)

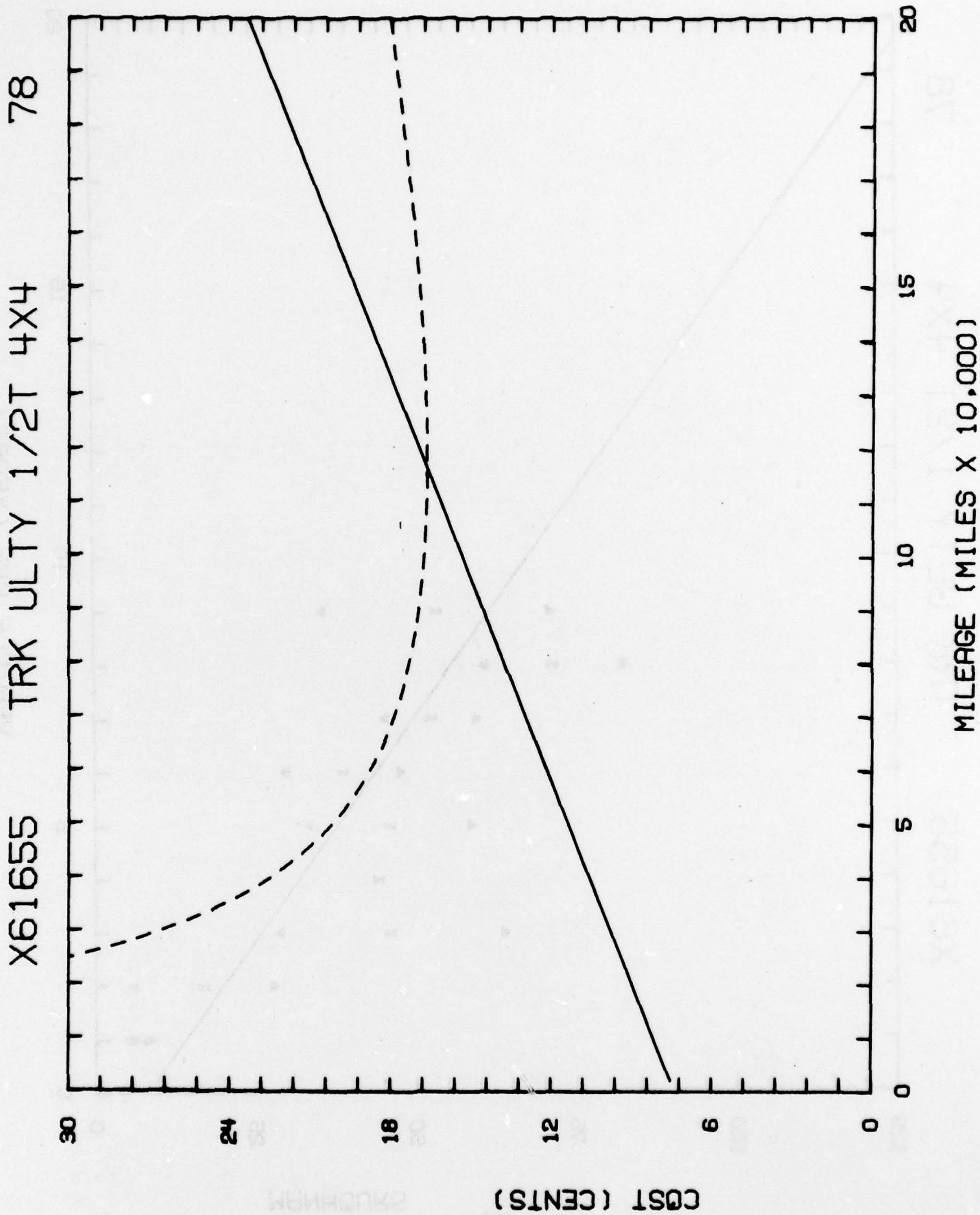

X61655 TRK ULTY 1/2T 4X4 78
MILES THIS YEAR
0
5000
10000
15000
20000
25000
VEHICLE AGE (YEARS)
0
5
10
15
20



X61655 TRK ULTY 1/2T 4X4 78
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)

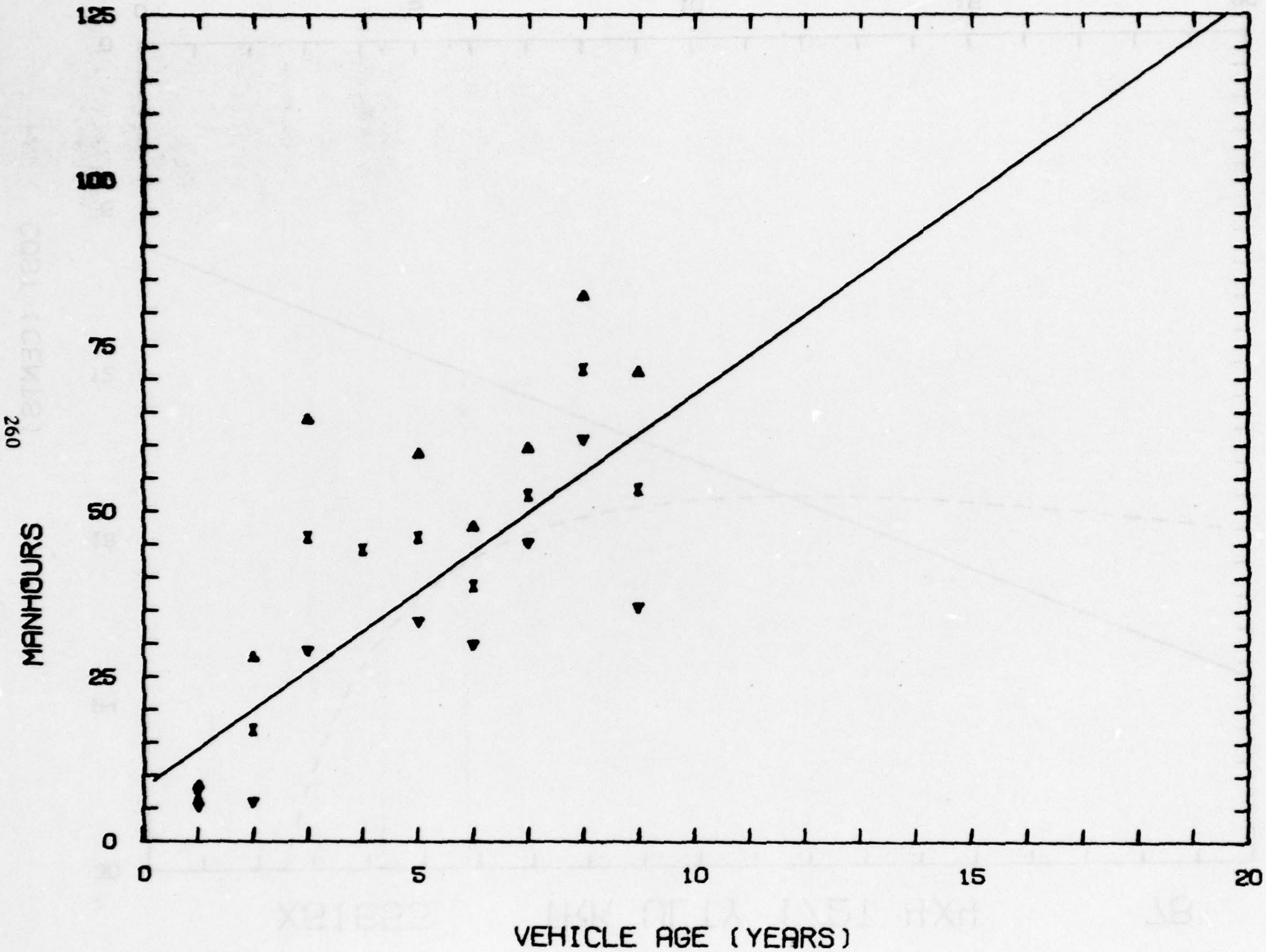


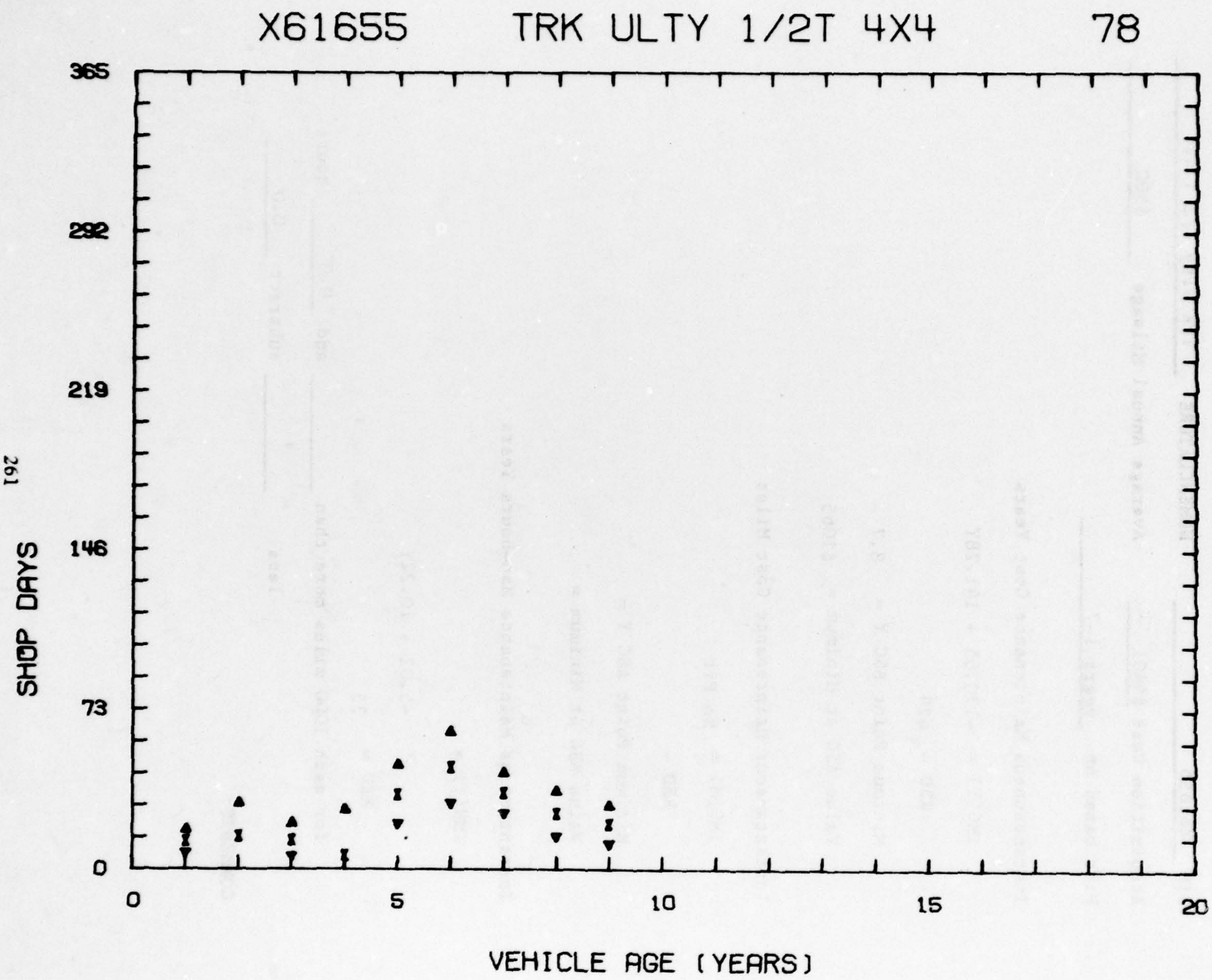
X61655 TRK ULTY 1/2T 4X4 78
COST (DOLLARS X 100)
30
24
18
12
6
0
0
5
10
15
20
VEHICLE AGE (YEARS)



X61655 TRK ULTY 1/2T 4X4 78
COST (CENTS)
MILEAGE (MILES X 10,000)
0
6
12
18
24
30
0
5
10
15
20

X61655 TRK ULTY 1/2T 4X4 78





X61655 TRK ULTY 1/2T 4X4 78
365
292
219
146
73
0
SHOP DAYS
0
5
10
15
20
VEHICLE AGE (YEARS)

DATA SOURCE TRADOC 77

LIN X61655 NOMENCLATURE Trk Ulty 1/2 T 4x4

Acquisition Cost $5401 Average Annual Mileage 5300

Fits based on years 1-7

Instantaneous Maintenance Cost Years

IMC(Y) = -170.55 + 141.28Y

RSD = 429

Minimum Point ASC Y = 8.7

Value ASC at Minimum = $1065

Instantaneous Maintenance Cost Miles

IMC(M) = No Fit

RSD =

Minimum Point ASC Y =

Value ASC at Minimum =

Instantaneous Maintenance Man-hours Years

IMH(Y) =

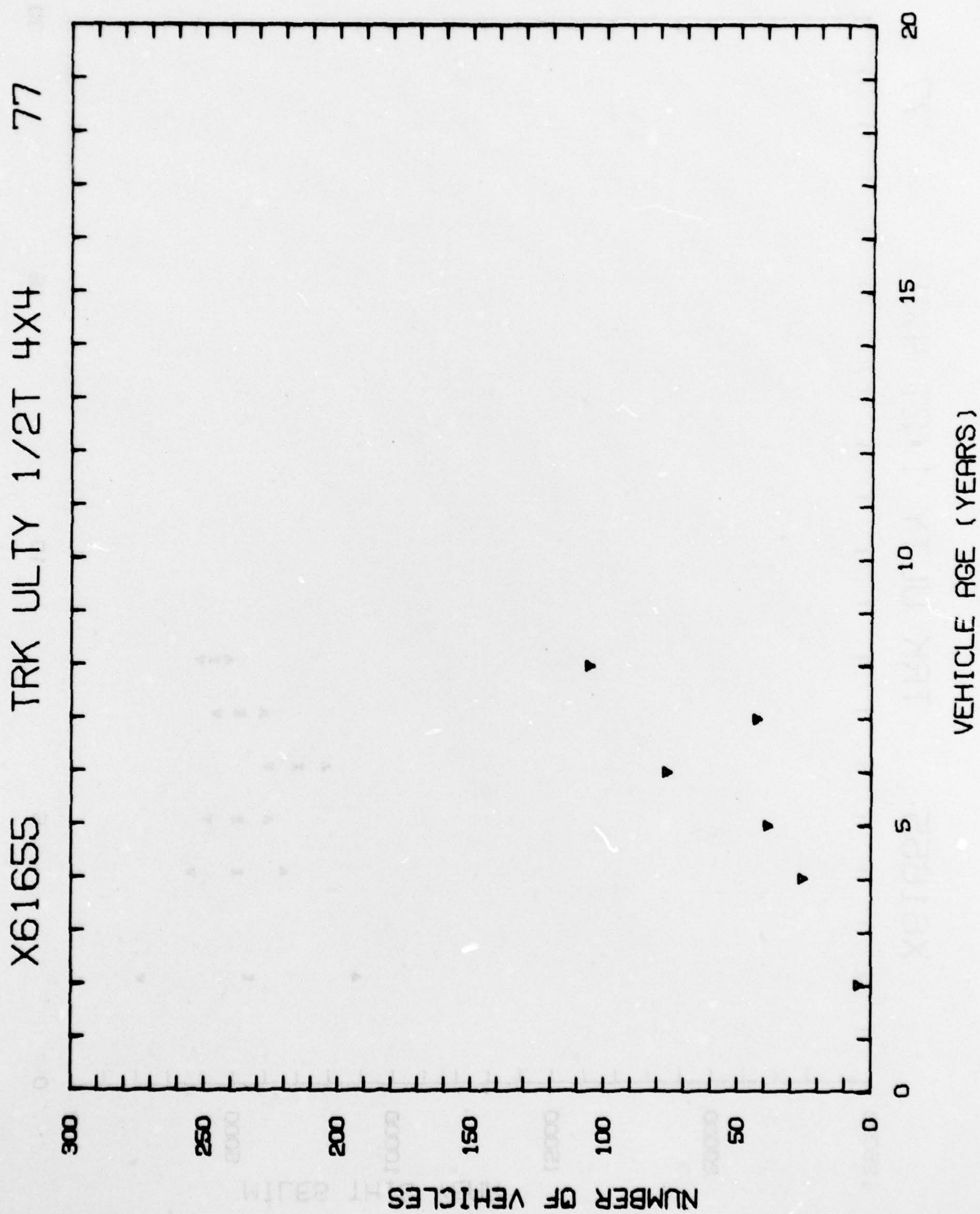
= -5.02 + 10.22Y

RSD = 35

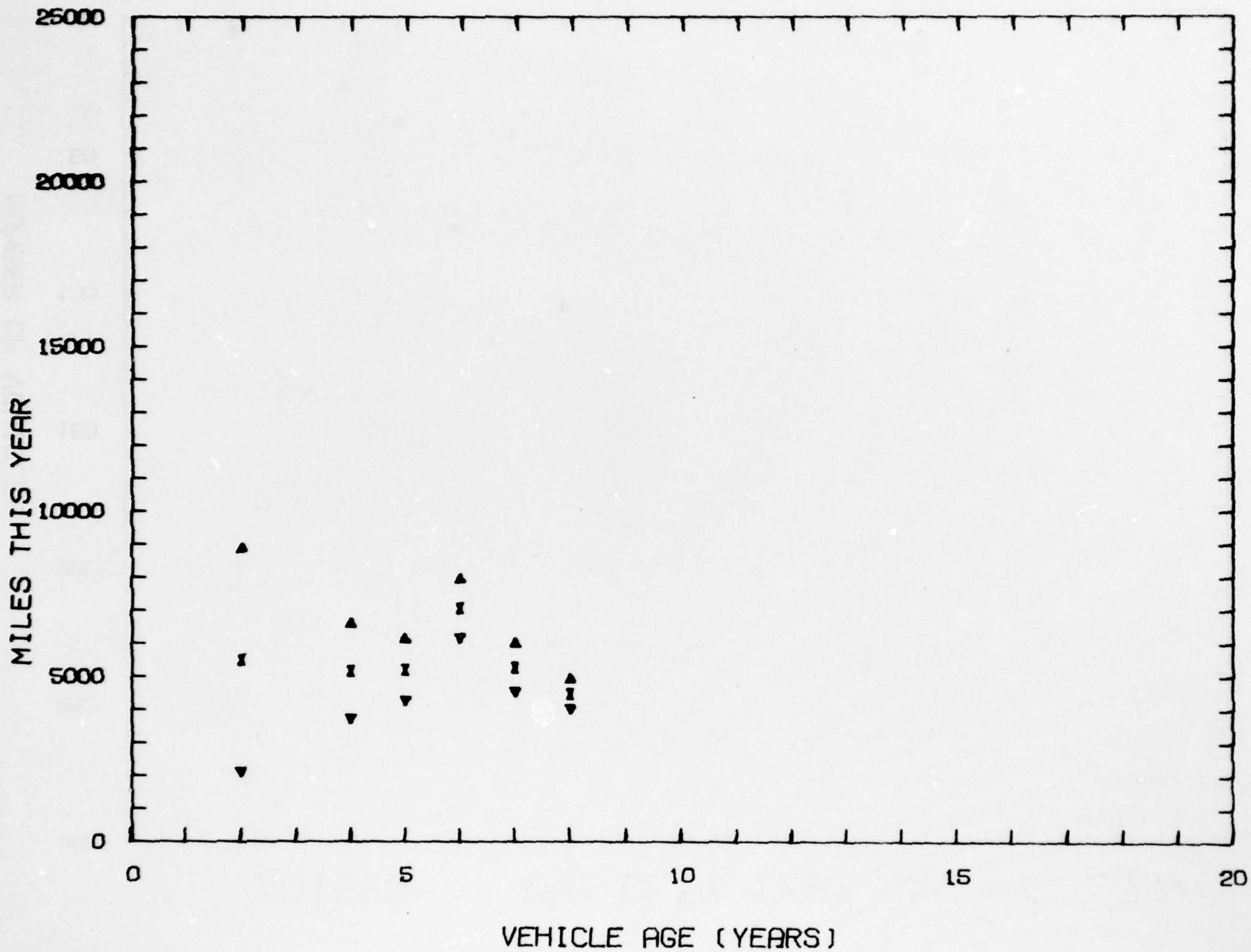
for each 1000 miles more than ______ add 0.0 hours

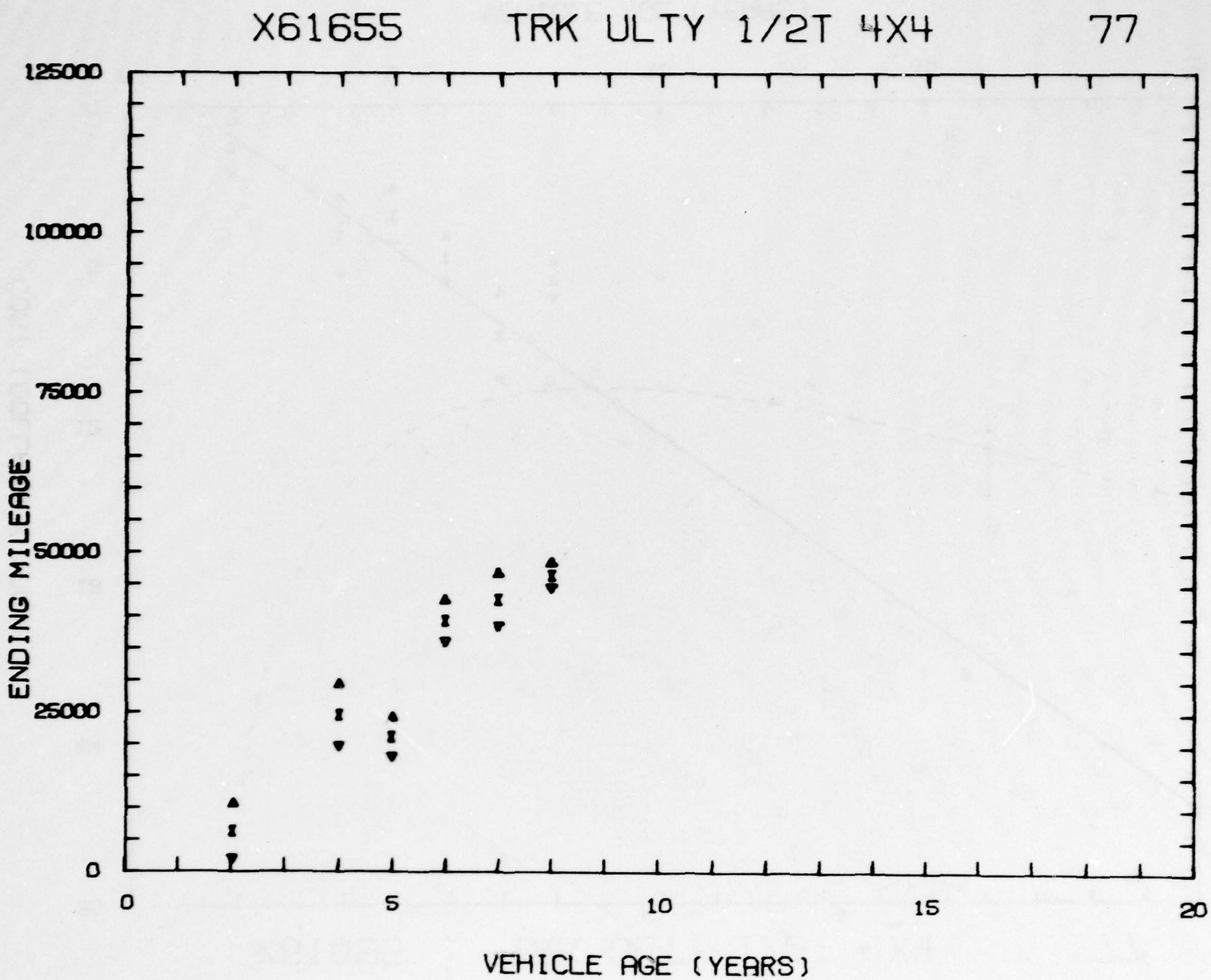
less ______ subtract 0.0

COMMENTS:

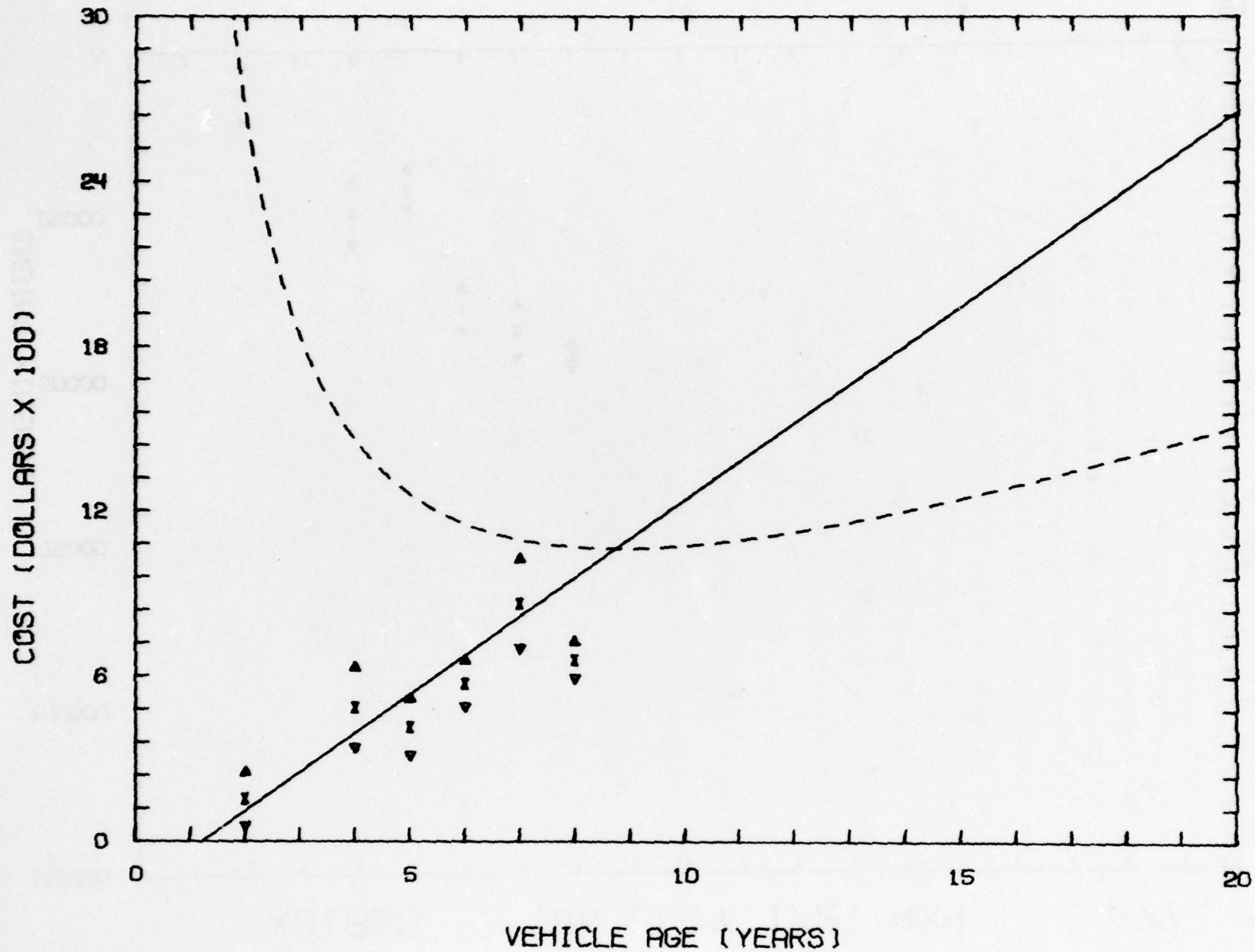

X61655 TRK ULTY 1/2T 4X4 77
NUMBER OF VEHICLES
VEHICLE AGE (YEARS)
0
50
100
150
200
250
300
0
5
10
15
20

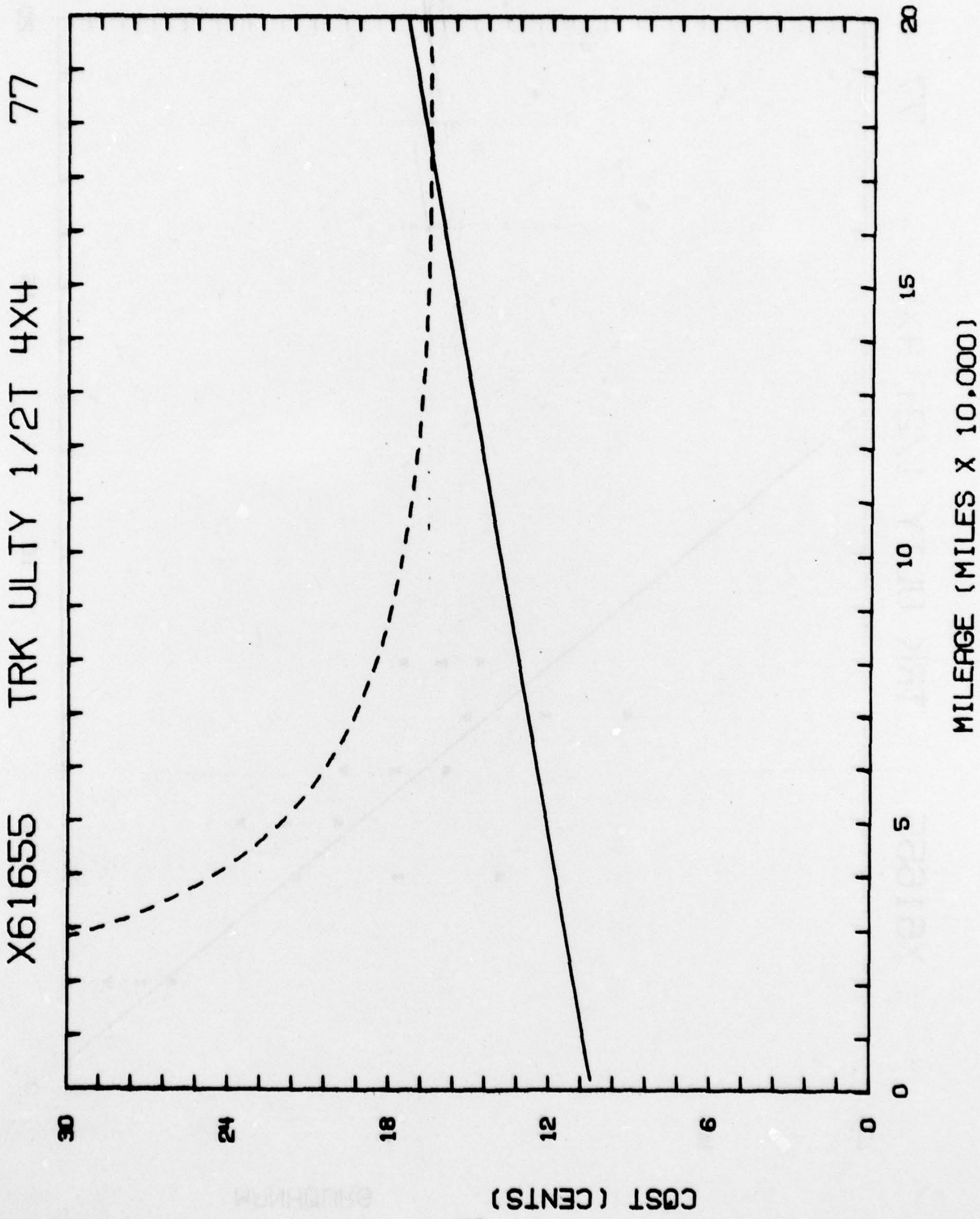
X61655 TRK ULTY 1/2T 4X4 77

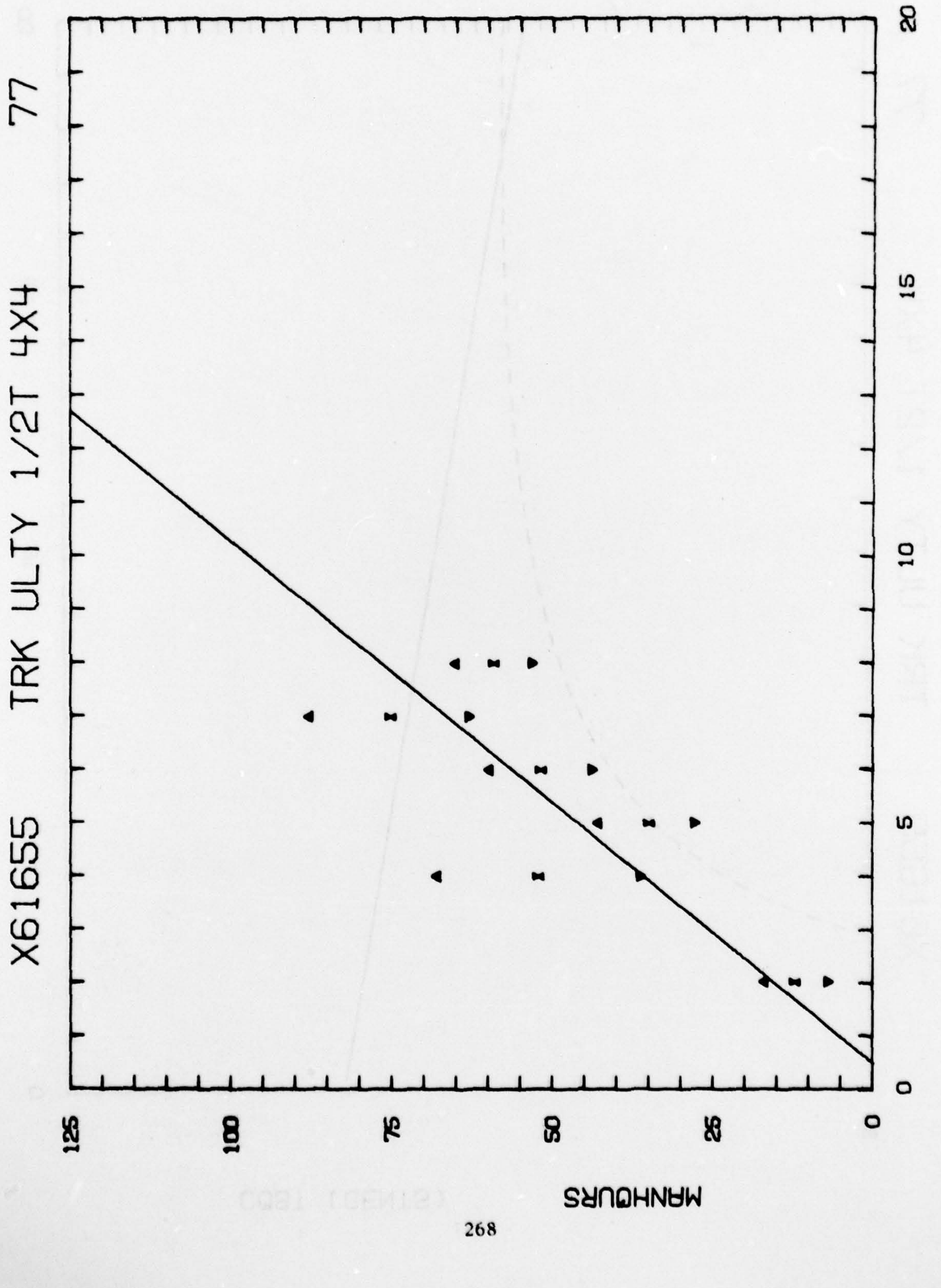


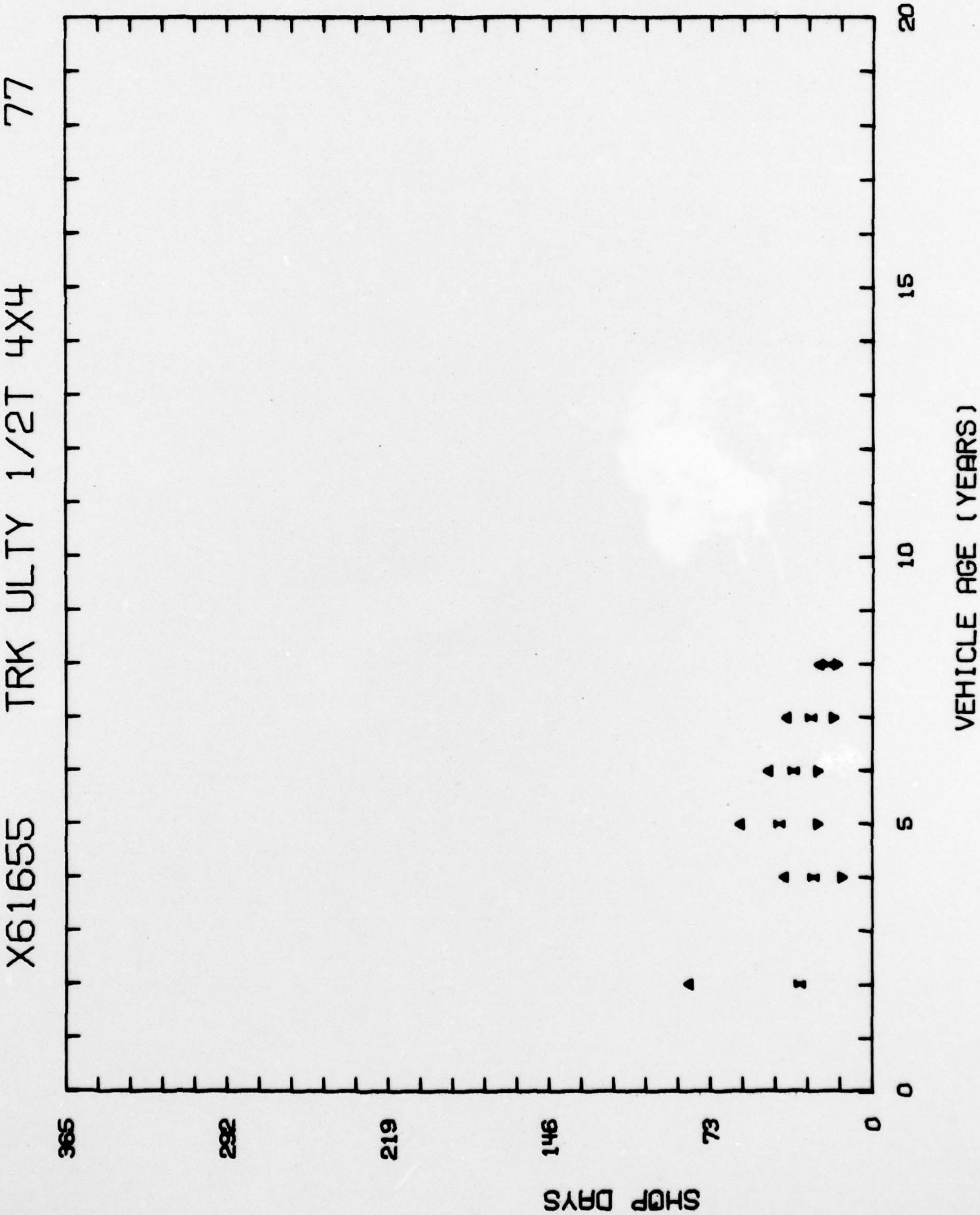

X61655 TRK ULTY 1/2T 4X4 77
125000
100000
75000
50000
25000
0
ENDING MILEAGE
0
5
10
15
20
VEHICLE AGE (YEARS)

X61655 TRK ULTY 1/2T 4X4 77




X61655 TRK ULTY 1/2T 4X4 77
COST (CENTS)
30
24
18
12
6
0
0
5
10
15
20
MILEAGE (MILES X 10.000)


X61655 TRK ULTY 1/2T 4X4 77
MANHOURS
0
25
50
75
100
125
VEHICLE AGE (YEARS)
0
5
10
15
20



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